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Study of

JET AIRCRAFT EMISSIONS AND AIR QUALITY IN THE VICINITY OF THE LOS ANGELES INTERNATIONAL AIRPORT

for

ENVIRONMENTAL PROTECTION AGENCY

Contract No. CPA 22-69-137

by

AIR POLLUTION CONTROL DISTRICT

COUNTY OF LOS ANGELES

April 1971

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The results of an investigation of the impact of jet aircraft operations on the air environment in the vicinity of a major air terminal are presented. This study,made at Los Angeles International Airport during the period of June 30, 1969, through November 18, 1970, had the following objectives: to determine total pollutant emissions from aircraft and ground operations at a major airport; to conduct exhaust measurements on the Pratt and Whitney JT4A and JT9D enegines to complete the available exhaust emission data for gas turbine engines; to measure atmospheric concentrations of pollutants at ground level within and around a major airport; and, to determine the carbon monoxide exposure in an aircraft cabin during all ground operations.

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PROJECT PERSONNEL

LOS ANGELES COUNTY - AIR POLLUTION CONTROL DISTRICT

RALPH E. GEORGE - PROJECT DIRECTOR

JOHN S. NEVITT - ASST. PROJECT DIRECTOR

PRINCIPAL PARTICIPANTS

JULIEN A. VERSSEN

M. F. BRUNELLE
R. M. BURLIN
I. CHERNIACK
E. L. FISHER
W. D. HOLLAND
J. A. MOSHER
T. P. MULLINS
J. R. TAYLOR

ENVIRONMENTAL PROTECTION AGENCY

ELBERT C. TABOR - PROJECT OFFICER

AIR POLLUTION CONTROL OFFICE

DIVISION OF AIR QUALITY AND EMISSION DATA

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INTRODUCTION

This report presents the results of an investigation of the impact of jet aircraft operations on the air environment in the vicinity of a major air terminal. The Los Angeles County Air Pollution Control District conducted the study as a contractual effort for the Environmental Protection Agency. The study made at Los Angeles International Airport during the period June 30, 1969, through November 18, 1970, had as its objectives to:

- Determine total pollutant emissions from aircraft and ground operations at a major airport;
- Conduct exhaust measurements on the Pratt and Whitney JT4A and JT9D engines to complete the available exhaust emission data for contemporary gas turbine aircraft engines;
- Measure atmospheric concentrations of pollutants at ground level within and around a major airport;
- Determine the carbon monoxide exposure in an aircraft cabin during all ground operations.

CONCLUSIONS

AIRCRAFT AND GROUND OPERATIONS

- Jet flights account for 53 per cent of the total atmospheric pollution burden generated within the boundary of Los Angeles International Airport (LAX). About 90 per cent of the particulate matter and 72 per cent of the hydrocarbons in this total originate from jet sources.

- Ground operations account for 42 per cent of total air contaminant emissions and 55 per cent of total carbon monoxide emissions at LAX.

- LAX is a significant area source of air contaminants, generally upwind of metropolitan Los Angeles. Total emissions within the 4.7 square mile airport area are 122 tons per day, or an emission density of 26 tons/day/square mile. Aircraft using LAX emit an additional 45 tons/day below 3500 feet altitude in Los Angeles County but outside of the airport boundary.

- The 6.7 tons of particulate matter emitted daily in the 4.7 square mile LAX source area exceeds the atmospheric loading rate of particulates from any area of comparable size in Los Angeles County.

- Based on flight time surveys and the JT4A and JT9D engine test data, 70 per cent of flight time to and from 3500 feet altitude is in the idle and taxi mode, which also accounts for about 60 to 70 per cent of total emissions from these engines.

- Though particulate emissions for the JT4A engine are very conspicuous during both final approach and take-off, about 60 per cent of average total flight particulate emissions below 3500 feet occurs during taxi and idle modes after arrival touchdown and and before initiating the take-off run. This and the previous conclusion emphasize the gains that could be achieved by minimizing engine running time on the ground.

- The JT8D engine emits total air contaminants at a rate about twice that of any of the other six models tested. Its 35 per cent portion of the engine flights at LAX thus accounts for 55 per cent of total emissions from all jet flights at the airport.

- The new "smokeless" JT9D turbofan engine, which powers the 747 superjet, emits less visible emissions and about the same total weight of air contaminants per flight as the lower thrust JT4A turbojet and JT3D turbofan engines used on B-707 and DC-8 aircraft, and one-half of the total for the unmodified JT8D turbofan engine mounted on the short-haul B-727, -737 and DC-9 aircraft.

ATMOSPHERIC MEASUREMENTS

- One result of airport activities is an increased soiling effect. Atmospheric contamination measurements of particulates by Km show significantly higher values in the airport area (30-67 Km x 10) than at a location several miles removed, such as Downtown Los Angeles (23-34 Km x 10), although total weight of particulate material, Hi-Vol, varies little between the areas.

- Monthly average carbon monoxide (CO) values at Downtown Los Angeles (4-6 ppm) and Lennox (6-7 ppm) are within the range of ambient concentrations measured at the airport stations (2-18 ppm).

- Atmospheric CO levels average 4 to 11 ppm in areas adjacent to and circumscribing the airport complex. Generally, carbon monoxide levels were higher east and east-northeast (downwind) of the airport. These values are within the range of concentrations observed at fixed sampling sites within the airport boundary.

- CO levels at paired inside-outside sampling locations, with one exception, are higher at the inside station. Statistical analysis indicates that higher internal readings are caused by undetermined emission sources.

- Highest monthly average ground level CO concentration of 18 ppm was observed outside Ticketing Building No. 7, close to heavy auto traffic. The emission inventory indicated that auto traffic is an appreciable contributor to the observed contaminant levels and should be considered in any appraisal of the impact of an airport on the surrounding community.

- Mobile lab sampling at sites surrounding and adjacent to the airport area shows increasing Km particulate values (soiling effect) from the ocean, upwind of the airport, to a maximum immediately downwind of the airport. CO values are more randomly distributed and tend to be higher along major auto traffic routes.

AIRCRAFT CABIN TESTS

- During runway operations, carbon monoxide concentrations in an aircraft cabin are comparable to airport background values and significantly lower than levels to which the air traveler is exposed during his stay at the air terminal prior to taxiing onto the runway.

SCOPE OF WORK

To accomplish the objectives of this study, the following work was performed:

A. Aircraft Emissions

Emissions estimates were developed of the total quantities of air pollutants emitted annually from air carrier and general aviation aircraft at LAX in the following categories:

1. Turbojet, turbofan and turboprop commercial transports.
2. Piston-engine commercial transports.
3. Piston-engine private aircraft.

Emission data for gas turbine engine commercial transports were developed from specific engine tests. Measurements of carbon monoxide, oxides of nitrogen, hydrocarbons and other organic gases, and particulates, were made during operating modes that simulated idle or taxi, take-off, climb-out and landing. Emissions from piston-engine aircraft were estimated using available engine exhaust emission data.

B. Ground Operations Emissions

Emissions estimates were made of annual pollutant emissions from the following ground operations at LAX:

1. Aircraft fueling systems.
2. Service vehicles.
3. Aircraft engine run-up during maintenance and ground-check.
4. Motor vehicles within the airport complex.
5. Miscellaneous sources.

Emission tonnage data for these ground sources were developed by utilizing available source test data with present source classification survey information.

C. Atmospheric Measurements

Measurements were made of ambient concentrations of carbon monoxide and suspended particulates at fixed and mobile sites at outside airport locations, inside airport terminals, and in the area immediately adjacent to the airport. Two of the outside fixed sites were selected to measure background levels for comparison with values recorded at other locations with higher exposure potential.

Sampling at the fixed sites was continuous to encompass normal, low and peak periods of aircraft and vehicular traffic at the airport. Periods when high pollution potential existed in the Los Angeles area were also included.

Outdoor ambient air measurements were made with a mobile air monitoring laboratory in areas adjacent to, and circumscribing the airport complex. Sampling was conducted each weekday and on six week-end days, for a continuous six-hour period at each preselected site.

The air sampling instruments were located in three major areas as follows:

1. Passenger Terminal Locations

   a. Satellite No. 2, adjacent to the north runway

      - Two carbon monoxide instruments, for inside and outside air sampling.
      - Two "Km" particulate matter instruments, for inside and outside air sampling.
      - One pair of "Hi-Vol" particulate matter instruments for outside air sampling.

   b. Satellite No. 7, adjacent to the south runway

      - Two carbon monoxide instruments, for inside air and outside air sampling.

- Two "Km" particulate matter instruments, for inside air and outside air sampling.
- One pair of "Hi-Vol" particulate matter instruments for outside air sampling.

c. Ticketing Building No. 7 - adjacent to vehicle parking area

- One carbon monoxide instrument for inside air sampling.
- One carbon monoxide instrument for outside air sampling (October-November only).
- Two "Km" particulate matter instruments for inside air and outside air sampling.

d. Control Tower - adjacent to vehicle parking area

Outside air sampled with:

- One carbon monoxide instrument.
- One "Km" particulate matter instrument (October-November only).
- One pair of "Hi-Vol" particulate matter instruments.

2. Background Locations (Outside Air)

a. Federal Aviation Administration V.O.R. Site - near the west end of the south runway

- One carbon monoxide instrument.
- One "Km" particulate matter instrument.

b. Security Office Site - northeast of the airport complex

- One carbon monoxide instrument.
- One "Km" particulate matter instrument.

3. Mobile Air Monitoring Locations

Outside air was sampled at 26 sites with one carbon monoxide instrument and one "Km" particulate matter instrument.

D. Jet Engine Tests

Tests were made of pollutants in the exhaust from each of two Pratt and Whitney aircraft gas turbine engines--a JT4A mounted on a United Air Lines DC-8 aircraft and a JT9D mounted on an American Airlines 747 aircraft. Static tests were conducted using sampling and analytical methods developed and utilized in previous studies of jet aircraft by the Los Angeles County Air Pollution Control District (APCD). Emission data were developed for carbon monoxide, oxides of nitrogen, hydrocarbons and other organic gases, and particulate matter. Two replicate tests were conducted on each engine during the simulated operating modes of idle or taxi, take-off, climb-out and landing.

E. Aircraft Cabin Tests

Carbon monoxide concentrations were measured in a United Air Lines 727 aircraft cabin while the plane boarded passengers and performed all runway taxi and idle operations up to the point of take-off.

AIRCRAFT AND GROUND OPERATIONS

Estimates were developed of the total quantities of air pollutants emitted annually from aircraft and all ground operations within the boundary of Los Angeles International Airport (LAX). This boundary is outlined on Figure 18, which is associated with the Atmospheric Measurements section of the report. For 1970, these emissions totaled 44,530 tons in this 4.7 square mile area. Aircraft emissions were 25,595 tons, or 57.5 per cent, and ground operation emissions were 18,935 tons, or 42.5 per cent of the total.

BASIS FOR AIRCRAFT EMISSIONS ESTIMATE

Jet aircraft emissions were based on number of flights, engine type, average time in each operational mode, and analyses of engine exhausts. Table I shows the estimated number of flights at LAX for 1970.

Jet aircraft emissions estimates were developed from information obtained on flight counts, aircraft type, and engine type and model, in a survey in mid-1970 of commercial air carriers operating at LAX.

Piston-powered aircraft emissions were estimated from monthly flight count data supplied by the Department of Airports, fuel consumption rates for each operational mode obtained from the FAA, and exhaust emission factors for uncontrolled motor vehicle engines.

TYPE AND NUMBER OF GAS TURBINE AIRCRAFT ENGINES AT LAX

Table II shows survey estimates of the total number of gas turbine aircraft engines, by type, in use at LAX in 1970. Engine models are divided into seven groups, each containing an engine tested by APCD and assumed to have exhaust emissions representative of that group. Also shown are the engine manufacturer and the make and model of aircraft on which the engine is mounted.

ARRIVAL TIME

Average observed time, in minutes, required to descend from 3,500 feet altitude to touchdown on the runway by jet-powered aircraft operated at LAX in 1970 is shown in Table III. The average arrival time for 41 turbofan aircraft observed was 5.1 minutes (range--2.5 to 7.0 minutes); for 10 turbojets, 5.8 minutes (range--3.3 to 10 minutes); and for 2 turboprop aircraft, 5.5 minutes.

The altitude parameter of 3,500 feet was selected because air contaminants emitted above this altitude are not considered to contribute materially to the air pollution problem in Los Angeles County. Aircraft altitude was established by radio communication from the FAA Control Tower with the pilot and elapsed times were measured by stopwatch and coordination of visual, radar, and radio-monitored observations.

DEPARTURE TIME

The average observed time, in minutes, required to take-off and climb-out to 3,500 feet altitude by jet-powered aircraft operated at LAX in 1970 is shown in Table IV. For 40 turbofan aircraft observed, the average departure time was 2.7 minutes, with extremes of 1.2 and 5.2 minutes; 11 turbojets, 3.3 minutes with a range of 1.5 to 4.5 minutes; and for 2 turboprop aircraft, the average was 5 minutes. When the aircraft reached 3,500 feet altitude, the pilot notified the tower by radio and elapsed times were then measured by stopwatch and coordination of visual, radar, and radio-monitored observations. Climb-out time from 2,000 to 3,500 feet altitude averaged 1.1 minutes in all cases, based on an earlier APCD study. Table V summarizes the arrival and departure times.

TAXI AND IDLE TIME

The average time, in minutes, spent in idling and taxiing on the ground for both arrival and departure regimes is shown in Table VI. Based on 32 observations of departing aircraft, taxi and idle times averaged 14.1 minutes, with a range of 3.5 to 25 minutes. For 16 arriving aircraft, taxi and idle time averaged 6.7 minutes, with a 3 to 17 minute range.

Aircraft emissions during idling and taxiing, before and after each flight, are included with aircraft flight operations, not airport ground operations.

AVERAGE EMISSION RATES OF AIR CONTAMINANTS FROM A JT4A TURBOJET ENGINE AND A JT9D TURBOFAN ENGINE

Average emission rates, in pounds per minute, of particulate matter, carbon monoxide, oxides of nitrogen, combustible organic gases, and sulfur dioxide when the JT4A and the JT9D engines were operated in the simulated operational modes of taxi-approach, climb-out and take-off are presented in Table VII. Contaminant emission rates were developed from engine tests; sulfur dioxide emission rates were calculated from usage and analysis of the kerosene-type jet fuel. Complete test results for these two engines are included in Appendix.

Table VIII shows the weighted average rates of emission of air contaminants in pounds per average flight for a JT4A gas turbine aircraft engine. Figures 1 and 2 show views of sampling the exhaust from a JT4A turbojet engine and the positioning of the sample probes. The emission value for an "average flight" is the arithmetic average of the emission rates for a departure flight and an arrival flight. A "departure flight" consists of: taxiing from the passenger loading terminal; take-off to 2,000 feet altitude; and climb-out from 2,000 feet to 3,500 feet altitude. An "arrival flight" consists of: descent from 3,500 feet altitude to touchdown on the runway; and taxiing to the passenger unloading terminal.

Although the pounds of air contaminant emissions are not equal for arrival and departure flights, emissions of the two flights may be averaged when computing flight emission data because for each arrival, there is normally a matching departure flight. As described here, then, the sum of the emissions from an "arrival flight" and a "departure flight" is equal to the emissions from two "average flights".

Data in Table VIII indicate that about 70 per cent of the flight time to and from 3,500 feet altitude is spent in the idle or taxi mode, which also accounts for about 70 per cent of the total emissions from a JT4A turbojet engine. The idle or taxi mode is responsible for about 59 per cent of the particulate matter emissions, 85 per cent of the carbon monoxide, 10 per cent of the nitrogen oxides, 85 per cent of the combustible organic gases, and 34 per cent of the sulfur dioxide.

Table IX shows the development of weighted average rates of emissions of air contaminants in pounds per average flight for a JT9D gas turbine aircraft engine. Both Tables VIII and IX show the development of the weighted average rate of emission for each air contaminant when these gas turbine aircraft engines are operated in static tests to simulate operations of taxiing on the ground, approaching the airport on arrival, taking off from the airport on departure, and climbing out to attain altitude after take-off. Several views of the JT9D turbofan engine and the sampling equipment are shown in Figures 3 through 6.

Table IX data show that about 73 per cent of JT9D arrival and departure flight time below 3500 feet is in the idle or taxi mode. Emissions during this mode account for 59 per cent of total JT9D flight emissions.

AIR CONTAMINANTS EMITTED BY JET AIRCRAFT AT LAX

Table X shows the total annual tons of air contaminants emitted into the atmosphere of Los Angeles County by gas turbine aircraft engines operated at LAX during 1970. These emission data were developed from tests made on the following engines:

Turbofan	-	P & W JT3D, JT8D, JT9D
Turbojet	-	P & W JT3C-6, JT4A
	-	General Electric CJ805
Turboprop	-	Allison 501 D

There is a noticeable difference in visible emissions from various engines, with the new engine, the JT9D, emitting practically no visible emissions. The JT8D engine emits the greatest amount of visible emissions, as well as emitting total air contaminants at the highest rate of the seven models of jet engines tested. The JT8D engine population is now being retrofitted with new "smokeless" combustors which greatly reduce both visible and invisible emissions.

Some interesting comparisons between gas turbine aircraft engines can be made from the data presented in Table X:

- The JT8D engine emits total air contaminants at a rate about twice that of any of the other six models tested. Its 35 per cent portion of the engine flights at LAX thus accounts for 55 per cent of the total emissions from all jet flights at LAX.

- The new "smokeless" JT9D turbofan engine, which powers the 747 superjet, emits less visible emissions and about the same weight of air contaminants per flight as the lower thrust JT4A turbojet and JT3D turbofan engines used on B-707 and DC-8 aircraft and only about one-half of the total for the unmodified JT8D turbofan engine mounted on the short-haul B-727, 737 and DC-9 aircraft.

DEVELOPMENT OF AIR CONTAMINANT DATA FOR PISTON-POWERED AIRCRAFT OPERATED AT LAX

Time and mileage parameters for both departure and arrival of four-engine piston-powered commercial aircraft operated at LAX are presented in Table XI. Similar information is given for two-engine piston-powered aircraft (12,500 pounds and heavier) in Table XII. Observations made from the FAA Control Tower established the average time these aircraft were in the following operational modes:

- Taxiing, after loading, to the end of the runway and idling while awaiting flight clearance.
- Take-off and climb-out to 3,500 feet altitude.
- Descent from 3,500 feet altitude to touchdown on the runway.
- Taxiing from touchdown to the unloading terminal.

Average rates of gasoline consumption during the various operational flight modes for four-engine and twin-engine (12,500 pounds and heavier) piston-powered aircraft are based on data obtained from the FAA and shown in Table XIII. The average amount of aviation gasoline used per flight within Los Angeles County by four-engine piston-powered aircraft is 117 gallons and by twin-engine piston-powered aircraft is 48 gallons. Development of these amounts is shown in Tables XIV and XV. Survey data show that helicopters use an average of 18 gallons per flight.

To assess the air pollution contribution of piston-powered fixed-wing aircraft and all helicopters (piston and turbine) operated at LAX, average emissions of air contaminants were estimated by applying data for uncontrolled motor vehicles, as shown in Table XVI. Results of applying these emission factors to average gasoline consumed per flight by four-engine and two-engine fixed-wing aircraft and helicopters are given in Tables XVII, XVIII, and XXI.

For single-engine and light twin-engine (less than 12,500 pounds) piston-powered aircraft, the average rate of fuel consumption includes the rate for cruising as well as take-off, climb-out, approach, and taxiing. These planes are powered by 100 to 230 horsepower engines and use an average of 3.6 gallons of gasoline per flight. This quantity of fuel consumed per flight is based on data obtained from the FAA and confirmed by airport managers from gasoline sales to this type of aircraft and the number of flights at their airports. Pertinent data on these aircraft are shown in Table XIX. By applying the average emission factors from Table XVI to gasoline use per average flight by single-engine aircraft, the average rate of air contaminants emitted in pounds per flight is obtained as shown in Table XX.

Tables XXII through XXV give the average amounts of air contaminant emissions into the atmosphere of Los Angeles County from piston-powered aircraft operated at LAX in 1970. The amounts are shown both in pounds per year and tons per year by contaminant for each aircraft type.

RECAPITULATION OF AIR CONTAMINANTS EMITTED PER YEAR BY ALL AIRCRAFT OPERATED AT LAX

Table XXVI presents estimated tons per year (1970) of all contaminants emitted into the Los Angeles County atmosphere below 3,500 feet altitude by air carrier aircraft and by general aviation aircraft operated at LAX. Table XXVI accounts for all measured air contaminants emitted during taxiing, take-off, climb-out, and approach modes of operation. Emissions are shown by contaminant and aircraft type, each with totals.

Since an altitude parameter of 3,500 feet is used, not all emissions from aircraft using LAX are within the airport boundary; thus, for the purpose of this study, the following adjustments are made:

> Adjustment to determine the amount of air contaminant emissions from jet-powered aircraft operated within the LAX boundary.
>
> On take-off, the average jet-powered aircraft operated at LAX has flown approximately 4 horizontal miles is ascending to 2,000 feet altitude. However, when it reaches the boundary of LAX, it has flown only 2.5 horizontal miles. Therefore, 2.5/4, or 62.5 per cent of the amount of air contaminants emitted by jet-powered aircraft on take-off are included in the tabulation adjusted to account for emissions within the LAX boundary. Air contaminants emitted by jet-powered aircraft during climb-out are not included in the adjusted figures, as they occur beyond the boundary of LAX.
>
> On arrival, the average jet-powered aircraft is approximately 13 horizontal miles from touchdown when it is at 3,500 feet and at the airport boundary about 1.7 horizontal miles from touchdown. Therefore, 1.7/13, or 13.1 per cent of the air contaminants emitted by jet-powered aircraft on descent are included in the adjusted airport figures.

Average tons per year of air contaminants emitted by jet-powered aircraft within the airport study area are presented in Table XXVII.

Adjustment to determine amount of air contaminant emissions from piston-powered aircraft operated within the LAX boundary.

Commercial piston-powered transports include four-engine aircraft, two-engine aircraft 12,500 pounds and heavier, and helicopters. On take-off and climb-out, the average commercial four-engine and two-engine piston-powered aircraft has flown approximately 13 horizontal miles in ascending to 3,500 feet. Passing the LAX boundary, however, it has flown 2.5 horizontal miles. Therefore, 2.5/13, or 19.2 per cent of the emissions on take-off and climb-out by commercial four-engine and two-engine piston-powered aircraft occurs within the study area.

On arrival, the average commercial four-engine and two-engine piston-powered aircraft is approximately 10 horizontal miles from touchdown when it is at 3,500 feet. At the airport boundary, it is about 1.7 horizontal miles from touchdown. Therefore, 1.7/10, or 17 per cent of the flight emissions of commercial four-engine and two-engine piston-powered aircraft occurs within the LAX boundary.

These adjustments for emissions from jet-powered aircraft and commercial four-engine and two-engine piston-powered aircraft were rather straightforward. However, adjustments of emissions from helicopters and single-engine piston-powered aircraft could not be made in the same manner because of differences in operation and flight patterns for these aircraft. As an only approach, it was assumed that 5 per cent of the emissions in Los Angeles County for these two types of aircraft was emitted in the study area.

Adjusted average tons per year of air contaminants emitted by commercial piston-powered aircraft within the boundary of LAX are presented in Table XXVIII.

RECAPITULATION OF AIR CONTAMINANTS EMITTED PER YEAR BY ALL AIRCRAFT OPERATED WITHIN THE BOUNDARY OF LAX

Emissions generated annually by turbojet, turbofan, and turboprop engines within the LAX boundary below 3,500 feet altitude are shown in Table XXIX. Turbojets in this category include the JT3C-6 (water injected), JT4A, CJ805-3B, JT3C-7, and Dart 7. Turbofans include the JT3D, JT8D, JT9D, and CJ805-23. The turboprop data are for the 501D engine. Table XXIX also summarizes 1970 emissions from all aircraft in the study area. Piston-engine commercial transports include four-engine aircraft, two-engine aircraft 12,500 pounds and heavier, and helicopters. Piston-engine private aircraft include single-engine and twin-engine aircraft lighter than 12,500 pounds.

SUMMARY OF EMISSIONS FROM GROUND OPERATIONS WITHIN THE BOUNDARY OF LAX

Estimated emissions from the following ground operations are shown in Table XXX:

- 139 aircraft fueling stations.
- 1,217 pieces of internal combustion power-operated ground service equipment.
- 189 motor vehicles in airport use.
- 15,330 gas turbine aircraft engine "run-ups" per year, for an average of 25 minutes each.
- 92,328,000 motor vehicles entering and leaving the airport boundary per year and consuming about 7,590,000 gallons of gasoline per year within the area.
- Miscellaneous sources including: abrasive blast cabinets, baghouses, boilers, degreasers, loading racks, multiple-chamber incinerators, paint bake ovens, paint spray booths, floating roof tanks, underground tanks, and vapor recovery systems.

RELATIVE CONTRIBUTION OF AIR CONTAMINANTS FROM ALL AIRCRAFT AND GROUND OPERATIONS WITHIN THE LAX BOUNDARY

The relative contribution of air contaminants from each major source category: commercial transports (turbine and piston), private aircraft, and collateral ground operations;are summarized in Table XXXI. From ground operations, the largest contribution to total emissions is by motor vehicles which enter and leave the airport boundary. For total emissions of each contaminant in the airport area, Tables XXX and XXXI show that motor vehicles are responsible for about 36 per cent of all carbon monoxide, 29 per cent of all oxides of nitrogen and 11 per cent of all combustible organic gases. Aircraft account for about 91 per cent of the 6.7 daily tons of particulate matter emissions, 44 per cent of the carbon monoxide, 53 per cent of the nitrogen oxides, 73 per cent of the combustible organic gases, and 73 per cent of the sulfur dioxide. Total emissions from the 4.7 square mile airport area average 122 tons per day. In addition, aircraft--particularly jet-powered--cause practically all visible emissions and most of the odors and noise at LAX.

Finally, jet flights produce 53 per cent of the total atmospheric contaminant loading within the airport boundary, and all aircraft using LAX emit an additional 45 tons per day below 3500 feet in Los Angeles County but outside the airport boundary.

BASIS FOR ESTIMATED EMISSIONS OF AIR POLLUTANTS FROM GROUND OPERATIONS

Data presented in this portion of the study indicate that emissions from ground operations are a quite significant portion of total pollutants emitted annually at LAX. Carbon monoxide emissions from ground operations are more than 55 per cent of total CO emissions from all sources. In view of this, it is important that any studies or inventories directed at airport contributions to the atmospheric pollution burden include considerations for emissions from ground operations.

Aircraft emissions during idling and taxiing, before and after each flight are included with aircraft flight operations, not airport ground operations.

Estimates were developed of the total quantities of air pollutants emitted annually from the following sources at LAX:

Aircraft Fueling Systems

Aircraft are fueled at the six satellites at LAX by means of hydrant fueling systems. Fueling by this system instead of trucks eliminates the truck filling losses from conventional loading operations. At the day storage area there are twenty-three 39,000 gallon underground storage tanks that act as surge vessels to supply petroleum distillate to the satellite area. The tanks receive product via pipeline for storage prior to pumping to hydrant fueling stations at the satellites.

Planes are fueled from the hydrants by "go-trucks" equipped with flexible quick-coupling line sections, meters, and filters. Jet fuel is loaded "bottom-wing" while aviation gasoline is loaded "top-wing". All pumps are equipped with mechanical seals to prevent hydrocarbon losses and are automatically controlled to provide a continuous supply of fuel to the satellites. The satellites have a series of hydrant fueling systems, each with several spouts for fueling aircraft. All spouts are below grade, have tight fitting metal covers, and are closed with quick-coupling valves.

Fueling system emissions are the uncontrolled combustible organic gases. Currently there are 139 aircraft hydrant fueling stations, each calculated to emit about 2.2 pounds of hydrocarbons per day, for a total of 306 pounds per day or 56 tons per year.

Operation of Gasoline-Fueled Ground Service Equipment

There are 1,217 units of gasoline-fueled ground service equipment at LAX, or an average of about 2½ units for each jet aircraft using the airport. Although a few equipment units use diesel fuel, it was assumed that all were gasoline-fueled.

The power-operated ground service equipment consists of: light and heavy duty trucks, tractors, sweepers, vans, tow tugs and trucks, air starters, belt loaders, transports, portable air compressors, 400-cycle power generators, fork lifts, cranes, welders, fuel-metering trucks, aerial ladders, steps, work platforms, etc.

Most of this service equipment is owned and operated by airlines or the airport, but several service organizations supply rental equipment to airlines who make limited use of LAX.

These 1,217 pieces of ground-operated service equipment each consume an average of 6.6 gallons of gasoline per day, or totals of 8,030 gallons per day and 2,930,950 gallons per year.

In addition to the power-operated ground service equipment, there are 189 motor vehicles in daily service at LAX. Gasoline consumption for sixteen pre-1963 model vehicles, which are uncontrolled, was added to that for ground-operated service equipment. At 2 gallons per day each, these 16 motor vehicles use 11,680 gallons of gasoline per year, making an annual total of 2,942,630 gallons used by uncontrolled internal combustion engines. By applying the emission factors for uncontrolled motor vehicles, this service equipment is estimated to emit the amounts of air contaminants shown in Table XXXII.

The 173 (189 - 16) 1963 and later model vehicles are also assumed to each use 2 gallons per day, or a total of 126,290 gallons of gasoline per year. Using the appropriate factors, these controlled (some crankcase only and some both exhaust and crankcase) motor vehicles were estimated to emit the air contaminant amounts shown in Table XXXIII.

The combined total annual estimated emissions of air contaminants from gasoline- fueled ground service equipment are:

	Tons/Year (Rounded)
Particulate Matter	20
Carbon Monoxide	4,245
Nitrogen Oxides	200
Combustible Organic Gases	905
Sulfur Dioxide	12
TOTAL	5,380

Gas Turbine Aircraft Engine Run-Up During Maintenance and Ground-Check

On an average day at LAX, 42 gas turbine aircraft engines are run-up during typical maintenance and ground-checks. These engines are tested almost entirely in idle and cruise modes and are stabilized at various power settings for periods sufficient to heat the oil and check for leaks. The tests are conducted with the cowling removed. Table XXXIV shows the length of time these engines are operated and the percent of time in each mode.

Each of the forty-two engines was operated for an average of 25 minutes per day, giving a total of 1,052 engine minutes daily for "run-up" operations.

For estimating the emissions from gas turbine aircraft engine run-ups during maintenance and ground-checks, the run-up operations were assumed to be 75 per cent idle mode and 25 per cent cruise mode. Estimated emissions are shown in Table XXXV.

Aircraft Start-Up and Taxi to and From Maintenance Areas

On an average day a total of 42 aircraft are started up and taxied between the maintenance areas and satellite terminals. Each aircraft at LAX has an average of 3.36 gas turbine engines, so these 42 planes represent 141 engines. The average taxiing time is 10 minutes per aircraft, which gives 1,410 total engine minutes per day at taxi operating mode. Table XXXVI shows the estimates of emissions from these operations.

A summation of the estimated amounts of air contaminants emitted by jet aircraft engines during run-up and maintenance ground-check, and also when taxiing between maintenance areas and satellite terminals is presented in Table XXXVII.

Vehicles Entering and Leaving the Airport Boundary

Daily motor vehicle traffic on World Way was obtained from 1967 traffic count data compiled by the Accounting Division of the Department of Airports. World Way West traffic was assumed to be the arithmetic average of the count on Pershing Drive north and south of World Way West. The daily traffic on Avion Drive and Private Century Boulevard was estimated from parking lot counts for this area. Counts for other traffic flowing across the boundary of LAX were obtained from detailed flow maps in a recent airport traffic study by the City of Los Angeles. Traffic counts were measured in both directions at several check points for the city study. Distances between these points were measured to the nearest 0.1 mile with a calibrated odometer for the present vehicle mileage estimate. The daily vehicle count was multiplied by the mileage between check points to arrive at the daily motor vehicle miles. These daily motor vehicle miles were increased by an estimated 16 per cent to allow for driving in parking lots, on service roads, and on streets for which there were no available data. Also a 3.5 per cent adjustment was made to allow for traffic increase between 1967 and 1970. Using this procedure, total travel within the LAX boundary was estimated to be 291,150 vehicle miles per day--Table XXXVIII.

Assuming an average automobile obtains 14 miles per gallon of gasoline, the daily 291,150 vehicle miles represents a daily consumption of 20,796 gallons of gasoline, or 7,590,540 gallons per year. The annual estimated emissions of air contaminants from gasoline-fueled motor vehicles entering, leaving, and operating within the LAX boundary are shown in Table XXXIX.

Emission factors used for motor vehicles were based on extensive test data produced by the State of California and incorporate an allowance for carburetor "hot-soak" and tank evaporation losses. Thus, no losses were added for parked cars; but as a matter of interest, the number of parking spaces available and estimated number of cars parked daily are presented in Table XL. Public pay parking facilities are increasing rapidly and the airport plans to increase their own VSP lot from 2,400 to 6,000 parking spaces in the near future.

Miscellaneous Sources of Air Pollution

Tons per year of air contaminants contributed by the following miscellaneous sources are shown in Table XLII and were estimated as follows:

Abrasive Blast Cabinets -

This equipment is used to remove scale, sand, paint, carbon, and other adherent material from the surface of articles with an impelled stream of abrasive material. The equipment consists of an enclosure, rotary table, abrasive supply and handling equipment, and blast or impeller equipment.

Four abrasive blast cabinets emit an estimated 3.2 pounds of particulate matter per working day or an annual total of 0.4 tons.

Baghouses -

Baghouses are box-like structures containing cloth or glass fiber tubes, envelopes, or bags through which particulate-laden gas is passed to filter dust or fumes. These devices are extremely effective for controlling most dusts or fumes.

Five baghouses are used to control emissions from abrasive blast cabinets and zyglo developing system -- emissions are negligible.

Boilers -

Boilers, or vapor generators, contain a combustion chamber in which heat from an open flame is utilized to generate vapor within a confined system. Of six oil-fired boilers within the boundary of LAX, four are rated at 200 HP and two at 500 HP. Two of the 200 HP boilers operate 14 hours per day, 5 days per week and two operate 12 hours per day, 7 days per week. Both 500 HP boilers operate continuously. All emissions of air contaminants from these boilers were based on an average day of operation and calculated with the following factors:

	Pounds/Hour/100 HP
Particulate Matter	0.618
Carbon Monoxide	0.0049
Nitrogen Oxides	2.4719
Hydrocarbons (Comb. Org. Gases)	0.097
Sulfur Dioxide	2.207

On a calendar-day basis, these six oil-fired boilers emit 203 pounds of particulate matter, 2 pounds of carbon monoxide, 811 pounds of nitrogen oxides, 32 pounds of hydrocarbons, and 724 pounds of sulfur dioxide. Total air contaminants emitted by these boilers is 1,770 pounds per average day, or 325 tons per year.

Chrome Plating Tanks -

Chrome plating is the process of immersing metal objects into electrolytic solutions of chromic acid to deposit a thin surface coating of chromium which serves as a protective and decorative finish.

Air contaminants emitted by chrome plating operations are acid mists entrained by hydrogen and oxygen bubbles released electrolytically and are controlled by commercial mist inhibitors, surface active agents, or water wash scrubbers. Three chrome plating tanks in use are controlled to allow no air contaminant emissions.

Degreasers -

This equipment is used to remove oil, grease, or wax from metal objects. Heat applied to a tank of chlorinated hydrocarbon solvent causes solvent vapor to rise to the level of a water cooled condensing ring. Metal objects are lowered into the hot solvent vapor which condenses onto the cold surface of the metal object, thereby dissolving grease, oil, or wax. As the condensate drains off, it carries the soil from the metal object. Air contaminants emitted by vapor degreasers are chlorinated hydrocarbons which can be controlled by a vapor recovery system.

Ten vapor degreasers at LAX each emit from 2 to 170 pounds per day of chlorinated hydrocarbons. Collectively, these ten vapor degreasers emit 274 pounds of chlorinated hydrocarbons per working day, or an average of 28 pounds each per working day (5 days per week). Emissions were established by engineering surveys and observations and total an estimated 36 tons per year.

Filling Vehicle Tanks -

There are 43 underground gasoline storage tanks ranging in size from 1,000 gallons to 25,000 gallons capacity and having a combined capacity of 328,000 gallons. Total gasoline throughput is estimated to be two tankage volumes per month. Losses resulting from filling vehicle tanks with gasoline pumped from these storage tanks is estimated to be 345 pounds per day or 63 tons per year.

Loading Racks -

Loading racks are used to transfer bulk liquid petroleum distillate from storage tanks to delivery tanker trucks. These racks consist of pumps, filter separators, and counter-balanced loading arms with swivel joints, loading valves and drop tubes for submerged filling.

There are twenty loading racks emitting 693 pounds of hydrocarbons per day, or an average of 35 pounds per rack per day. Individual racks emit from less than one pound to as much as 160 pounds of hydrocarbons per day depending on throughput and distillate handled. Emissions were established by engineering observations and for these twenty loading racks totaled an estimated 127 tons per year of hydrocarbons.

Multiple-Chamber Incinerators -

Incineration involves the disposition of combustible refuse by burning. Two multiple chamber incinerators at LAX burn an average of 1,077 pounds of refuse per day, or 197 tons per year. Multiple-chamber incinerators are designed to provide efficient and maximum combustion of the materials being burned, thereby emitting a minimum of air contaminants. A multiple-chamber incinerator is constructed in a series of three chambers, the first for ignition of the refuse, the second for turbulence and mixing, and the third for combustion of organic gases and fly ash collection.

Total annual emissions of 2.0 tons of air contaminants from the two incinerators consist of: particulate matter, 0.4 ton; carbon monoxide, 0.3 ton; nitrogen oxides, 0.3 ton; hydrocarbons and other organic gases, 0.4 ton; and sulfur dioxide, 0.3 ton.

Paint Bake Ovens -

A paint bake oven is a heated enclosure used industrially to dry or harden surface coatings by the evaporation of organic solvents at elevated temperatures ranging from 100 to 600°F.

Air contaminants emitted by this operation are hydrocarbons, organic solvent vapors, odors, and aerosols resulting from the partially oxidized and polymerized organic solvents.

Two paint bake ovens at LAX are estimated to emit 3.5 tons per year of hydrocarbons and other organic gases.

Paint Spray Booths -

Paint spray enclosures confine particulate matter and organic solvent vapors from the spray of atomized paints. Particulate matter is adequately controlled by baffle plates, filter pads and water spray curtains, but the organic solvent vapors are uncontrolled.

Based on engineering observations, the 25 paint spray booths at the airport emit from 2 to 107 pounds of organic solvents per working day or a daily average of 31 pounds of solvents each. Total emissions are 775 pounds of organic solvents per working day or 141 tons per year.

Tanks - Floating Roof -

Floating roof tanks are used for storing volatile material with vapor pressures in the lower explosive range to minimize potential fire or explosion hazards. These vessels also economically store volatile products with boiling points above atmospheric temperature. The roof floats on the liquid surface and rises and falls with the level in the tank, thereby minimizing vapor losses during tank breathing and filling.

Of ten floating roof tanks ranging in size from 5,000 to 18,000 barrels, five store aviation gasoline and five store jet fuel. Based on accepted calculation methods, the 45,000 barrels of avgas storage emits 340 pounds of hydrocarbons per day and the 87,000 barrels of jet fuel tankage emits 86 pounds per day. Total annual hydrocarbon emissions from the ten tanks is estimated to be 78 tons.

Tanks - Underground -

Underground tanks at LAX store a variety of products that emit air contaminants during filling. Vapor-air mixture is displaced to the atmosphere from these tanks at different concentrations depending on temperature, product type, filling method, etc. Submerged or bottom fill techniques reduce filling losses compared to splash filling, which enriches the vapors being displaced.

Capacities, materials stored, and estimated daily hydrocarbon emissions for the 82 tanks are shown in Table XLI.

From engineering calculations, the total filling loss from these tanks is estimated at 113 tons per year of hydrocarbons.

Vapor Recovery Systems -

These systems are designed to recover tank breathing and filling losses. Captured vapors are compressed and charged to an absorption unit for recovery of condensible hydrocarbons.

Each of two vapor recovery systems at LAX was calculated to emit 70 pounds of hydrocarbon vapor per day or an annual combined total of 26 tons.

Miscellaneous Equipment -

Emission estimates for separate miscellaneous items of equipment at LAX are:

- Water wash scrubber controlling acid mist from chrome plating tanks--negligible emissions.
- Meter prover facility--2 pounds of hydrocarbons per day.
- Oil-effluent water separation system to collect condensate and hydrocarbon material from water drains of the filter tanks for the fuel hydrant pumping system--negligible emissions.
- Waste hydrocarbon products disposal system--80 pounds of hydrocarbons per day.
- Titanium tetrachloride filling station--negligible emissions.
- Gasoline filter facility--negligible emissions.
- 10 HP cyclone exhaust system controlling fiberglass dust--negligible emissions.

These seven miscellaneous equipment items emit a total of 82 pounds of hydrocarbons per day or 15 tons per year.

Table XLII summarizes the miscellaneous sources of air contaminants located within the boundary of LAX and their emissions in tons per year of particulate matter, carbon monoxide, nitrogen oxides, hydrocarbons and other organic gases, and sulfur dioxide. These miscellaneous sources emit about 5 per cent of the total for all ground sources and 2 per cent of the total emissions from all ground and aircraft sources within the boundary of LAX and below 3,500 feet altitude. Emission summaries are shown in Tables XXX and XXXI.

ATMOSPHERIC MEASUREMENTS

DESCRIPTION OF PROGRAM

The objective of the atmospheric sampling program conducted at the Los Angeles International Airport (LAX) was to measure concentrations of carbon monoxide and particulate matter at ground level in the vicinity of and within the airport complex. Fixed station sampling sites were selected in the airport area to give representative diurnal concentration levels for a variety of aircraft, vehicular and human activities. Sampling was conducted on a 24-hour per day basis from May 10, 1970 to November 11, 1970. Mobile station sites were selected to determine the effect of airport activities on locations in the area adjacent to and circumscribing the airport. Atmospheric measurements were made at each of 26 sites on an average of five days selected at random over the seven-month period. Sampling was performed during the daytime for six-hour periods.

Carbon monoxide levels were determined at the fixed station and mobile laboratory sites with MSA, Model 200, long-path (approximately 1 meter) nondispersive infrared gas analyzers, as shown in Figure 7. Suspended particulates were measured by two types of instrumentation, the automatic Chaney Aerosol Recorder, "Km", shown in Figure 8, and the Curtin Hi-Volume Air Sampler, "Hi-Vol", shown in Figure 9.

The automatic Chaney Aerosol Recorder is designed to sample the atmosphere for approximately 55 minutes of each hour, thus permitting 24 hourly readings per day. The atmospheric sample is drawn through a strip type filter tape, Whatman No. 52, leaving suspended particulate matter as a deposit. Hourly deposits are measured using light absorption which is dependent both upon the quantity and nature (color, particle size, etc.) of the deposit. These values are reported in "Km" units. A Km unit value is defined as that deposit of particulates on a filter which produces an optical density of 0.1 when the deposit area is one square centimeter and the volume of air sampled is one cubic meter.

A Curtin Hi-Volume Air Sampler collects one 24-hour sample of suspended particulate matter per day. The sampling unit consists of an air blower and filter adapter housed in a protective shelter. Filters used in this project were Gelman, Type A, 8" x 10" sheets manufactured from micro-sized filaments of glass containing no binder. Particulate matter collected by the "Hi-Vol" method is reported in terms of weight of particulate matter per unit volume of air sampled, i.e., micrograms per cubic meter.

Nine fixed station sites were located in and around the airport complex (Figure 18) so data could be collected to show the impact of airport activities on pollutant concentrations at ground level. To establish background levels of carbon monoxide and Km particulates, one sampling site was placed near the west end of the south runways. This site, No. 204 (Figure 10) at the Federal Aviation Administration V.O.R. site near the beach, was upwind of all airport operations and not appreciably influenced by industrial or vehicular activity. These contaminants were also measured northeast (downwind) of the airport complex at the Security Office Site No. 209.

Control Tower Site No. 201 was adjacent to the west end of the vehicle parking area. This location was to provide data influenced by vehicle activity throughout the airport complex, including parking areas and World Way. Carbon monoxide and particulates by both Km and Hi-Vol were measured here.

Adjacent to and downwind of the south runways and taxiways, sampling operations were conducted at Satellite No. 7, which is the busiest passenger terminal at LAX. At outside Station No. 208 and inside Station No. 207, monitoring was conducted for both carbon monoxide and "Km" particulate levels. In addition, "Hi-Vol" particulate levels were monitored outside.

Sampling was conducted at Ticketing Building No. 7 located near vehicle traffic on World Way and downwind of the south runways and taxiways. This area also has high passenger traffic. Carbon monoxide and "Km" levels were measured inside, Site No. 206. Particulates both by "Km" and "Hi-Vol" were monitored outside, Site No. 205 as shown in Figure 11. In addition, carbon monoxide was monitored at Site 205 during October and November.

Satellite No. 2, adjacent to the north runways and taxiways, is the terminal for international flights and has a lower passenger volume than most other terminals. Because of its position on the north side of World Way, contaminant levels were expected to show the influences of vehicular and other activities in the center and west sections of the airport. Carbon monoxide and "Km" particulate matter were monitored both inside and outside at Sites Nos. 202 (Figure 12) and 203. Particulate matter was also monitored outside using a "Hi-Vol" instrument.

RESULTS

Fixed Stations

Hourly average data for Km and CO by month for each fixed sampling site are shown in Table XLIII. Also shown for comparison are data from APCD air monitoring stations at Lennox (Station No. 76) and Downtown Los Angeles. Locations of these sites are shown on the maps, Figures 18 and 19.

An examination of the data indicates that CO readings, with one exception, are higher at inside locations as compared to outside sites. The exception is the Ticketing Building No. 7, which is close to heavy auto traffic. Km values in general are about the same inside and outside. An inspection of diurnal Km data has shown that an increase in outside readings is followed by a similar increase at the inside locations. However, diurnal data for CO shows no such correlation, and there are frequent incidents of sharp increases in concentration at irregular hours. These peak inside CO readings were found to be caused by gasoline-powered maintenance equipment. However, this intermittent source was definitely not sufficient to account for the average inside readings being significantly higher than outside values. Other possible explanations for this phenomenon are human activity or facilities associated with operation of the terminal.

Comparison of outside values at the airport locations with those at Downtown Los Angeles and Lennox shows no significant difference in CO levels according to the area. Monthly average values at Downtown Los Angeles (4-6 ppm) and Lennox (6-7 ppm) are within the range of ambient concentrations measured at the airport stations (2-18 ppm). However, Km x 10 particulate values in the terminal area of the airport (30-67) are significantly higher than those recorded at Lennox (12-22) and Downtown Los Angeles (23-34). Some data on Hi-Vol particulate sampling in areas outside the airport indicates the weights of this suspended material at these locations is only slightly lower than those at airport locations. Thus, the impact of the airplane on the airport area seems to be one of a soiling effect from smoke plumes.

Cumulative frequency distributions of values for all hours of sampling Km and CO by stations are summarized for the months of June and October in Table XLIV which also includes data for the arithmetic mean and standard deviation. Similar data for the period of peak traffic activity (9 a.m. to 12 noon) and the period of low traffic activity (2 a.m. to 5 a.m.) are given in Tables XLV and XLVI. June was selected as a month typical of the early period of the survey, and data for October are reported to show the transition to higher wintertime levels of CO characteristic of the Los Angeles Basin area. In general, levels in October are roughly 20-30 per cent higher than in June. Typical curves for these frequency distributions are shown in Figures 20 and 21. These curves compare the upwind background levels at Station 204 with values for Station 208 outside Satellite 7, a high exposure area.

An examination of the 50 per cent points for June CO levels at all hours, and at peak hours, indicates that Stations 206 and 207 (inside Ticketing Building No. 7 and Satellite No. 7) are significantly higher than the other sampling locations. Background Stations 204 and 209 show the lowest levels, but are only slightly lower than other outside stations. The same pattern exists for October data at a somewhat higher CO level. This latter period, however, includes results from Station 205, outside Ticketing Building No. 7 near the street (World Way). CO data at this sample site were the highest of any found in this survey, probably due to the close location to a major vehicular source. Data for the hours of low traffic activity during June shows Station 207 with values appreciably higher than the others. Station 204 is the lowest, but again only slightly lower than other outside sampling. Values for October at these hours show little variation and fairly random distribution by location. It is interesting to note that at this time of low activity, traffic emissions were a minor factor, as evidenced by the data for Station 205 as compared to other locations.

Except for the background samples, the 50 per cent points of the Km particulate levels for total hours of sampling in June and October were fairly well distributed over the range of values. There is a trend toward inside levels being higher than those outside, but the differences are slight. Data for hours of peak activity in June and October again show that levels at the background stations are very low. Values for sites in the terminal area were fairly evenly distributed, with a high at Station 207 outside Satellite 7. Inside values were either about the same or slightly higher than outside levels. Data for the hours of low traffic activity in June follow the same pattern as for peak hours, with a narrower range of values. With the exception of Station 203 outside Satellite 2, Km levels for all the stations were about the same. Vehicular emissions for the three levels of airport activity were a minor factor in Km particulate values, since Station 205 exhibited none of the elevated levels found for CO.

A summary of paired data for three sets of inside-outside sampling of CO, and Km particulates, and a comparison of values upwind and downwind of the airport (the "background" Stations 204 and 209) are given in Tablex XLVII, XLVIII and XLIX for total hours of sampling and for the periods of peak and low airport traffic activity. In these tables are shown: the arithmetic mean of the hourly average values at each station for the month; the mean of the difference between the individual hourly average values of the inside and outside (or upwind and downwind) pairs, the standard deviation of these individual differences; the correlation coefficient for the pairs of data; the results of a statistical test (Student's T) to determine if the paired samples were drawn from the same statistical population or not (i.e., was the air inside a location actually different in nature or origin from that outside, or were the two simply parts of an air mass widely variable in composition).

Data for CO in Table XLVII (total hours of sampling) indicate that none of the sets of data comprises pairs drawn from the same population. However, most of the inside samples do show a significant correlation with the corresponding outside values. This indicates that the higher inside CO readings are the result of some undetermined emission source, probably internal, superimposed on a common inside-outside atmospheric burden. Examination of Km data indicates that some of the paired samples are from the same population, and all have a good correlation. Since more than one-third of the outside Km levels are higher than the inside values, there is no clear indication that undetermined sources of Km levels are contributing to higher inside readings, as is indicated in the CO data.

During peak and low traffic activity hours, the CO sampling showed in general the same type of pattern as for the total hours. There were a few sets of paired data that could possibly have been drawn from the same sample population, but most indicated an extraneous source of CO. Km at peak hours also followed the pattern of total hours, and data for low activity hours showed even less agreement between levels of CO and Km for inside-outside comparisons.

Equations for the line of best fit for the paired data are given in Table L. However, these are merely the mathematical expressions for the relationships that existed between the inside and outside data and do not indicate the degree of correlation of these data.

Frequency distributions for Hi-Vol sampling during the June and October months are given in Table LI. The seasonal effect which results in levels for October which are 20-30 per cent higher than those of June can be seen in these data, and in Figure 22, the plot of Station 208 values.

Mobile Sites

The APCD's mobile air monitoring laboratory was used to sample in general areas adjacent to and circumscribing the airport complex. Sampling was conducted each weekday during the morning and on six week-end days during the afternoon, for a continuous six-hour period at each of 26 preselected sites. Locations of these sites are given on Figure 18, and the dates of sampling are shown in Table LVII. Average Km and CO data for the total sampling at each site are summarized in Table LIII and shown in Figures 23 and 24.

Km particulate sampling with the District mobile laboratory within the airport complex and in the near vicinity has provided useful data. Location of the airport near the ocean and the nature of the prevailing winds make the airport complex an almost ideal operation for an "area source" study. Collected data support the idea that the particulate burden of the atmosphere is increased by emissions from airport ground activities together with aircraft emissions; i.e., by the presence of the airport complex.

A progression of sampling sites from the ocean inland to the airport and beyond shows progressively higher particulate levels, becoming a maximum immediately adjacent to and downwind of the airport. Sampling averages were 7, 18, and 44 Km units x 10 for Sites 31, 23, and 18, respectively. (See Figure 23). Other sites are quite probably influenced by many sources usually found in a metropolitan area. Generally, values measured at sites north and west of the airport complex, upwind, were lower than those measured at sites east of the complex. Levels for Downtown Los Angeles averaged 29 for the months of May through October.

Compared to the Km particulate levels monitored, carbon monoxide values (Figure 24) were narrower in range, and showed a more random pattern of distribution. The lowest CO average was 3 ppm, recorded at mobile Site 11 just northwest of the airport. The highest, 11 ppm, was found at Site 18, adjacent to and downwind of the airport. Generally, carbon monoxide levels were higher east and east-northeast (downwind) of the airport. Since mobile laboratory sampling was performed along city streets, values would be expected to show vehicular traffic influences and, in fact, the higher values were found along the more heavily traveled streets.

METEOROLOGICAL DATA

Table LIV contains a frequency distribution of observed daily inversion base heights, measured at 6 a.m. PST at LAX during the five-month period, June-October, 1970, along with monthly average temperatures and relative humidities for the hours 0600-1900. All are within normal limits for the months concerned. The month-to-month variation in heights is considered quite normal for the area, with the lowest and most intense inversions occurring in August, September, and October. This is in accord with inversion climatology for the Los Angeles area.

Wind directions and speed for the months of May through November 1970 are shown in Table LV. This table gives the percentage of the total time of observation that the wind was from each of 16 directions of the compass. The average wind speed is listed for each month during the project. Table LV also shows that the prevailing winds were from the west and west-southwest. Monthly average wind speeds ranged from a high of 9.1 m.p.h. for June to 8.1 m.p.h. for November, compared to long-term averages of 8.3 m.p.h. and 7.1 m.p.h. for these months. On the same basis, the wind direction appeared to follow a normal pattern throughout the sampling project.

There were no significant storms or low pressure systems transiting Southern California during the period. A trace of precipitation occurred one day in October--otherwise rainfall was nil.

AIRCRAFT CABIN TESTS

Carbon monoxide concentrations inside an aircraft cabin were measured during operating modes including the period when the aircraft boarded passengers prior to departure, departed the satellite onto the runway, and taxied on the runway until ready to take off.

To facilitate testing, an equipment package was mounted on a three-shelf laboratory cart as follows:

- Three 12-volt storage batteries were placed on the bottom shelf. These batteries with a 110-volt inverter were sufficient to supply all required power but house current was used when it was conveniently available.

- On the second shelf were mounted the inverter, charger to maintain the batteries at operating power, 1 liter per minute sample pump, amplifier and continuous strip chart recorder, and two small gas cylinders. One cylinder contained nitrogen gas for zeroing and one contained 50 ppm of carbon monoxide in nitrogen for spanning.

- On the top shelf, a 0-100 ppm carbon monoxide (MSA Lira Model 200) infrared analyzer with a 9-inch cell was mounted on foam rubber. A silica gel dryer and plastic flowmeter were also provided.

Testing was performed as follows:

Runway Operations -

On October 27, 1970,the equipment package was placed in the galley compartment of a B-727 aircraft (Figure 14) supplied by United Air Lines for this test. A long intake tube permitted sampling anywhere in the aircraft, including the pilot's compartment. Carbon monoxide concentrations were measured while the aircraft taxied to the runway and then either taxied or idled on the runway prior to take-off. This aircraft went through all ground operations of actual service except that no passengers were on board.

From its position in the UAL maintenance area near Satellite No. 7, the aircraft moved onto the runway, then taxied in line with other aircraft in actual service (Figure 15). The test aircraft then proceeded to the end of the runway as though it were going to take off, but instead of taking off, taxied down the runway and back to the maintenance area. This series of operations was performed twice.

The test was conducted between 10:45 a.m. and 12:00 noon during peak morning traffic. On the first run the test plane was immediately behind a two-engine DC-9 and a four-engine 707 for 17 minutes. CO concentration inside the cabin during this run ranged from 3 to 4 ppm, which was unchanged from the level measured when parked in the maintenance area.

For the second run, the test plane was behind two two-engine DC-9's for 12 minutes on the taxi-way and behind one for six minutes at the take-off spot. On the taxi-way the CO concentration in the cabin was 4 ppm for the first four minutes, increased to 7 ppm at the sixth minute, remained at 7 ppm until the tenth minute, and then returned to 4 ppm. During the period when the reading was 7 ppm, plastic bag samples were taken in the pilot's compartment and the rear of the passenger compartment. Tests on these samples using an instrument at a fixed monitoring site showed 7 and 8 ppm. Distinct exhaust odors were observed in the pilot's compartment when these samples were taken. While at the take-off spot behind one aircraft for six minutes, the CO concentration was 2 ppm. Figures 16, 17 and 18 show typical views from the pilot's compartment as a plane taxies in the take-off line-up.

In another experiment while the aircraft was parked in the maintenance area, cigarette smoke was blown directly at the sample intake of the instrument. The CO concentration reached 13 ppm for less than one-half minute, dropped to 5 ppm for four minutes, then returned to 3 ppm--the original reading.

Under the conditions of these tests, it was shown that the concentration of carbon monoxide inside an aircraft when taxiing and idling in the runway line-up prior to take-off ranged from 2 to 7 ppm and usually averaged 4 ppm. These levels are comparable to background values and significantly lower than average concentrations at the other airport monitoring sites.

Passenger Loading Operations -

On October 28, 1970, carbon monoxide concentrations inside aircraft cabins were measured while passengers were boarding from the satellite through the enclosed telescoping ramps. Daytime measurements were made at Gate Nos. 71, 73, 75, and 79 of Satellite No. 7. The equipment package was placed near the end of the enclosed ramp because house current was available and minimum vibration occurred due to passenger loading. The equipment package did not interfere with the passengers and the sampling tube was easily placed inside the aircraft without hindering passenger boarding procedures.

The concentration of carbon monoxide in the aircraft cabin was continuously measured while passengers boarded and until the ramp was withdrawn. This same test was performed at each of four gates circumscribing the satellite.

Carbon monoxide levels inside the aircraft cabin during passenger boarding from the satellite through closed ramps at each gate are compared with concurrent readings at the continuous monitoring site (Station No. 207) inside the satellite building near Gate 70.

LOADING OPERATION		CO CONCENTRATIONS - PPM	
At Gate Number	Time Started	In Aircraft	At Station 207 Near Gate 70
71	9:40 A.M.	10	11
73	11:30 A.M.	11	7
79	12:05 P.M.	6	6
75	12:35 P.M.	9-14	6

These test data indicate that CO concentrations in aircraft loading passengers at Satellite No. 7 are usually about 10 ppm. No smoking is allowed in the cabin during this operation. It can also be observed from the data that while loading at Gate 71 (through the enclosed ramp), the 10 ppm CO concentration measured in the aircraft compares closely with the 11 ppm measurement at Station 207, the fixed site near the adjacent Gate 70.

TABLE II

ANNUAL AVERAGE NUMBER OF JET POWERED AIRCRAFT FLIGHTS BY MAKE AND MODEL, AND NUMBER OF GAS TURBINE ENGINE FLIGHTS BY TYPE, AT LOS ANGELES INTERNATIONAL AIRPORT IN 1970

TYPE OF GAS TURBINE ENGINE	ENGINE MODEL NUMBER	MANUFACTURER OF GAS TURBINE ENGINE	MAKE AND MODEL OF AIRCRAFT ON WHICH THE ENGINE IS MOUNTED	NUMBER OF AIRCRAFT FLIGHTS(a) AT LAX PER YEAR	NUMBER OF ENGINES PER AIRCRAFT	TOTAL NUMBER OF ENGINES FLIGHTS AT LAX PER YEAR
Turbojet (water injection)	JT3C-6 *	Pratt and Whitney	Boeing 707	8,030	4	32,120
Turbojet (dry)	CJ805-3B*	General Electric	Convair 880	6,570	4	26,280
Turbojet (dry)	JT4A-11 *	Pratt and Whitney	Boeing 707	1,460	4	5,840
	JT4A-11	Pratt and Whitney	Douglas DC-8	11,626	4	46,504
	JT3C-7	Pratt and Whitney	Boeing 720	7,300	4	29,200
	Dart-7	Rolls Royce	Fairchild F27A	10,220	2	20,440
				30,606		101,984
Turbofan	JT3D *	Pratt and Whitney	Boeing 707	73,000	4	292,000
	CJ805-23	General Electric	Convair 990	422	4	1,688
	JT3D Pratt	Pratt and Whitney	Boeing 720	32,120	4	128,480
	JT3D	Pratt and Whitney	Douglas DC-8	52,266	4	209,064
				157,808		631,232
Turbofan	JT8D *	Pratt and Whitney	Boeing 727	124,830	3	374,490
	JT8D	Pratt and Whitney	Boeing 737	27,740	2	55,480
	JT8D	Pratt and Whitney	Douglas DC-9	29,200	2	58,400
				181,770		488,370
Turbofan	JT9D *	Pratt and Whitney	Boeing 747	12,336	4	49,344
Turboprop	501D-22 *	Allison	Lockheed L-100	5,840	4	23,360
			TOTALS	402,960		1,352,690

(a) A "flight" is either an arrival or a departure.

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* Means this engine model was tested.

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TABLE III

OBSERVED AVERAGE TIME, IN MINUTES, REQUIRED TO DESCEND FROM 3,500 FEET ALTITUDE BY JET POWERED AIRCRAFT OPERATED AT LAX, 1970

NUMBER	TURBOFAN	TURBOJET	TURBOPROP
1	4.0	4.0	4.0
2	7.0	6.0	7.0
3	4.3	3.3	
4	4.3	7.0	
5	4.3	5.0	
6	4.3	5.0	
7	4.3	10.0	
8	4.3	6.0	
9	5.0	6.0	
10	5.0	6.0	
11	7.0		
12	5.0		
13	4.0		
14	3.0		
15	4.0		
16	4.0		
17	3.0		
18	7.0		
19	7.0		
20	5.0		
21	5.0		
22	5.0		
23	5.0		
24	7.0		
25	6.0		
26	6.0		
27	6.0		
28	6.0		
29	6.0		
30	5.0		
31	5.0		
32	5.0		
33	5.0		
34	5.0		
35	5.0		
36	2.5		
37	5.5		
38	5.5		
39	5.5		
40	5.5		
41	5.4		
	207.8	58.3	11.0
	Ave. 5.1	Ave. 5.83	Ave. 5.5

TABLE IV

OBSERVED AVERAGE TIME, IN MINUTES, REQUIRED TO TAKE OFF AND CLIMB OUT TO 3,500 FEET ALTITUDE BY JET POWERED AIRCRAFT OPERATED AT LAX, 1970

NUMBER	TURBOFAN	TURBOJET	TURBOPROP
1	1.5	2.0	7.0
2	1.5	1.5	3.0
3	1.5	4.0	10.0
4	2.0	4.5	
5	2.0	3.0	Ave. 5.0
6	1.2	3.0	
7	1.2	4.0	
8	3.5	4.0	
9	2.0	4.0	
10	2.0	3.0	
11	2.0	3.0	
12	3.1	36.0	
13	2.0		
14	2.0	Ave. 3.3	
15	5.2		
16	3.0		
17	2.0		
18	2.5		
19	2.0		
20	2.0		
21	3.0		
22	3.0		
23	3.0		
24	3.0		
25	3.0		
26	4.0		
27	4.0		
28	4.0		
29	4.0		
30	4.0		
31	3.0		
32	3.0		
33	3.0		
34	3.0		
35	3.0		
36	2.0		
37	3.0		
38	3.0		
39	3.0		
40	3.0		
	108.2		
	Ave. 2.7		

TABLE V

ARRIVAL AND DEPARTURE FLIGHT DATA(a) FOR JET POWERED AIRCRAFT OPERATED AT LAX, 1970

	TURBOFAN POWERED MINUTES	TURBOJET POWERED MINUTES	TURBOPROP POWERED MINUTES
ARRIVAL FLIGHT			
from 3,500' altitude to touch-down(b)	5.1	5.8	5.5
DEPARTURE FLIGHT			
(1) from ground level to 2,000' altitude(c)	1.6	2.2	3.9
(2) from 2,000' to 3,500' altitude(d)	1.1	1.1	1.1
(3) from ground level to 3,500' altitude(e)	2.7	3.3	5.0

(a) Altitudes were established by radio communication from the FAA Control Tower with the pilot in the aircraft. Elapsed times were established with a stop-watch and coordination of visual, radar, and radio monitored observations.
(b) From Table III.
(c) By difference between line 3 and line 2.
(d) From an earlier study by the Air Pollution Control District of Los Angeles County.
(e) From Table IV.

TABLE VI

OBSERVED AVERAGE TIME, IN MINUTES, THAT JET POWERED AIRCRAFT SPEND IN IDLE AND TAXI AT LAX, 1970

NUMBER	DEPARTURE Idling Time At The Satellite And Taxiing Time From Satellite Until Take-Off	ARRIVAL Taxi Time From Touch-Down To Engine Shut Off At Satellite
1	10.0	12.0
2	16.0	6.2
3	5.2	9.0
4	18.0	3.2
5	20.0	3.0
6	5.5	6.0
7	25.0	3.4
8	23.0	4.8
9	6.7	17.0
10	23.0	9.0
11	23.0	2.4
12	6.5	5.6
13	23.0	7.0
14	23.0	5.3
15	11.0	5.5
16	23.0	8.5
17	23.0	
18	10.2	
19	19.0	
20	12.0	
21	6.1	
22	12.0	
23	13.0	
24	3.5	
25	14.0	
26	15.0	
27	3.5	
28	14.0	
29	11.0	
30	5.8	
31	17.0	
32	10.5	
	451.5	107.9
	Ave. 14.1	Ave. 6.7

TABLE VII

AVERAGE EMISSION OF AIR CONTAMINANTS,[a] IN POUNDS PER MINUTE PER GAS TURBINE AIRCRAFT ENGINE PER OPERATING MODE AT LOS ANGELES INTERNATIONAL AIRPORT, 1970

ENGINE MODEL NUMBER	PARTICULATE MATTER				CARBON MONOXIDE				OXIDES OF NITROGEN				COMBUSTIBLE ORGANIC GASES				SULFUR DIOXIDE[b]			
	TAXI	APPR-OACH	CLIMB OUT	TAKE OFF	TAXI	APPR-OACH	CLIMB OUT	TAKE OFF	TAXI	APPR-OACH	CLIMB OUT	TAKE OFF	TAXI	APPR-OACH	CLIMB OUT	TAKE OFF	TAXI	APPR-OACH	CLIMB OUT	TAKE OFF
JT4A (turbojet)	0.392	0.425	0.683	1.108	1.733	1.003	0.494	0.106	0.042	0.317	1.308	2.267	0.5	0.167	0.25	0.25	0.07	0.189	0.423	0.587
JT9D (turbofan)	0.3	0.734	0.834	1.525	1.35	0.442	0.122	0.135	0.042	0.708	3.5	6.417	0.4	0.128	0.2	0.242	0.072	0.259	0.549	0.72

(a) These emission rates are from the Los Angeles County Air Pollution Control District source test results except the sulfur dioxide.
(b) The sulfur dioxide emission rates are based on fuel analysis results and fuel usage.

TABLE VIII

AVERAGE EMISSIONS OF AIR CONTAMINANTS IN POUNDS PER FLIGHT FROM A JT4A TYPE TURBOJET GAS TURBINE AIRCRAFT ENGINE OPERATED AT LOS ANGELES INTERNATIONAL AIRPORT, 1970

OPERATIONAL MODE	Minutes in Mode	PARTICULATE MATTER		CARBON MONOXIDE		NITROGEN OXIDES		COMB. ORG. GASES		SULFUR DIOXIDE	
		Pounds Per Minute	Pounds Per Flight	Pounds Per Minute	Pounds Per Flight	Pounds Per Minute	Pounds Per Flight	Pounds Per Minute	Pounds Per Flight	Pounds Per Minute	Pounds Per Flight
DEPARTURE FLIGHT (to 3,500 feet altitude)											
Taxiing[(a)]	14.1	0.392	5.527	1.733	24.435	0.042	0.592	0.5	7.050	0.07	0.987
Take-Off (to 2,000 feet)[(b)]	2.2	1.108	2.438	0.106	0.233	2.267	4.987	0.25	0.550	0.587	1.291
Climb-Out (2,000 to 3,500 ft.)[(b)]	1.1	0.683	0.751	0.494	0.543	1.308	1.439	0.25	0.275	0.423	0.465
TOTAL POUNDS PER FLIGHT/ENGINE			8.716		25.211		7.018		7.875		2.743
ARRIVAL FLIGHT (from 3,500 feet altitude)											
Approach to touchdown[(b)]	5.8	0.425	2.465	1.003	5.817	0.317	1.839	0.167	0.969	0.189	1.096
Taxiing[(a)]	6.7	0.392	2.626	1.733	11.611	0.042	0.281	0.5	3.350	0.07	0.469
TOTAL POUNDS PER FLIGHT/ENGINE			5.091		17.428		2.120		4.319		1.565
TOTAL POUNDS PER COMBINED DEPARTURE AND ARRIVAL PER ENGINE			13.807		42.639		9.138		12.194		4.308
TOTAL POUNDS PER AVERAGE FLIGHT[(c)] PER ENGINE			6.903		21.320		4.569		6.097		2.154

(a) From Table VI.
(b) From Table V.
(c) An "Average Flight" is the arithmetical average of a departure flight and an arrival flight.

TABLE IX

AVERAGE EMISSIONS OF AIR CONTAMINANTS IN POUNDS PER FLIGHT FROM A JT9D TYPE TURBOFAN GAS TURBINE AIRCRAFT ENGINE OPERATED AT LOS-ANGELES INTERNATIONAL AIRPORT, 1970

OPERATIONAL MODE	Minutes In Mode	PARTICULATE MATTER Pounds Per Minute	PARTICULATE MATTER Pounds Per Flight	CARBON MONOXIDE Pounds Per Minute	CARBON MONOXIDE Pounds Per Flight	NITROGEN OXIDES Pounds Per Minute	NITROGEN OXIDES Pounds Per Flight	COMB. ORG. GASES Pounds Per Minute	COMB. ORG. GASES Pounds Per Flight	SULFUR DIOXIDE Pounds Per Minute	SULFUR DIOXIDE Pounds Per Flight
DEPARTURE FLIGHT (to 3,500 feet altitude)											
Taxiing[a]	14.1	0.3	4.230	1.35	19.035	0.042	0.592	0.4	5.640	0.072	1.015
Take-Off (to 2,000 feet)[b]	1.6	1.525	2.440	0.135	0.216	6.417	10.267	0.242	0.387	0.72	1.152
Climb-Out (2,000 to 3,500 ft.)[b]	1.1	0.834	0.917	0.122	0.134	3.5	3.850	0.2	0.220	0.549	0.604
TOTAL POUNDS/FLIGHT/ENGINE			7.587		19.385		14.709		6.247		2.771
ARRIVAL FLIGHT (from 3,500 feet altitude)											
Approach to touchdown[b]	5.1	0.734	3.743	0.442	2.254	0.708	3.611	0.128	0.653	0.259	1.321
Taxiing[a]	6.7	0.3	2.010	1.35	9.045	0.042	0.281	0.4	2.680	0.072	0.482
TOTAL POUNDS/FLIGHT/ENGINE			5.753		11.299		3.892		3.333		1.803
TOTAL POUNDS PER COMBINED DEPARTURE AND ARRIVAL PER ENGINE			13.340		30.684		18.601		9.580		4.574
TOTAL POUNDS PER AVERAGE FLIGHT[c] PER ENGINE			6.670		15.342		9.300		4.790		2.287

(a) From Table VI.
(b) From Table V.
(c) An "Average Flight" is the arithmetical average of a departure flight and an arrival flight.

TABLE X

AVERAGE ANNUAL TONS OF AIR CONTAMINANTS EMITTED BY GAS TURBINE AIRCRAFT ENGINES OPERATED AT LOS ANGELES INTERNATIONAL AIRPORT IN 1970

ENGINE MODEL NUMBER	TOTAL NUMBER OF ENGINE FLIGHTS PER YEAR AT LAX(a)	PARTICULATE MATTER		CARBON MONOXIDE		OXIDES OF NITROGEN		COMBUSTIBLE ORGANIC GASES		SULFUR DIOXIDE		TOTAL AIR CONTAMINANTS
		POUNDS PER AVERAGE FLIGHT(b)	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT(b)	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT(b)	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT(b)	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT(b)	TONS PER YEAR (rounded)	TONS PER YEAR (rounded)
JT4A	101,984	6.903	350	21.320	1,090	4.569	235	6.097	310	2.154	110	2,095
JT9D	49,344	6.670	165	15.342	380	9.300	230	4.790	120	2.287	55	950
JT3D	631,232	4.683	1,480	19.328	6,100	3.208	1,010	9.571	3,020	1.402	440	12,050
JT8D	488,370	6.618	1,615	10.164	2,480	3.605	880	57.862	14,130	1.421	345	19,450
JT3C-6	32,120	7.687	125	15.312	245	2.785	45	3.123	50	2.119	35	500
CJ805	26,280	6.282	85	1.811	25	3.025	40	34.273	450	1.747	25	625
501D	23,360	3.228	40	0.647	8	3.412	40	1.895	20	0.867	10	120
TOTAL	1,352,690		3,860		10,330		2,480		18,100		1,020	35,790

(a) From Table II.
(b) An "Average Flight" is the arithmetical average of a departure flight and an arrival flight. The values in the column are from Tables VIII, IX, and Source Test Data of the Los Angeles County Air Pollution Control District.

TABLE XI

AVERAGE OPERATIONAL DATA FOR COMMERCIAL FOUR ENGINE PISTON POWERED AIRCRAFT ARRIVING AT AND DEPARTING FROM LOS ANGELES INTERNATIONAL AIRPORT

PRE-FLIGHT AND	RANGE IN MILES[a]			ELAPSED TIME IN MINUTES[a]		
FLIGHT PARAMETERS	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE
Departure from airport to 3,500 feet altitude						
(1) Taxi from terminal to end of runway and await clearance from traffic control tower	-	-	-	6	10	8
(2) Take-off	-	-	-	0.5	1	0.8
(3) Climb-out	12	14	13	4.5	8	6.2
TOTALS	12	14	13	11	19	15
Arrival from 3,500 feet altitude to airport						
(1) Approach for landing to touch down on runway	9	11	10	5	7	6
(2) Touchdown to high speed turn-off and taxiing to terminal	-	-	-	3	5	4
TOTALS	9	11	10	8	12	10

(a) The data are from observations of commercial aircraft (piston powered, gasoline fueled) operations made in January 1961 and confirmed in 1964. Altitudes were established by radio communications with the pilot of the aircraft. Ranges of aircraft were established by radar observations in the FAA Control Tower at Los Angeles International Airport. Elapsed times were established with stopwatch and coordination of visual, radar, and monitored radio observations.

TABLE XII

AVERAGE OPERATIONAL DATA FOR COMMERCIAL **TWO** ENGINE PISTON POWERED AIRCRAFT ARRIVING AT AND DEPARTING FROM LOS ANGELES INTERNATIONAL AIRPORT

PRE-FLIGHT AND FLIGHT PARAMETERS	RANGE IN MILES[(a)]			ELAPSED TIME IN MINUTES[(a)]		
	MINIMUM	MAXIMUM	AVERAGE	MINIMUM	MAXIMUM	AVERAGE
Departure from airport to 3,500 feet altitude						
(1) Taxi from terminal to end of runway and await clearance from traffic control tower.	-	-	-	6	10	8
(2) Take-off.	-	-	-	1	1	1
(3) Climb-out.	12	14	13	5	9	7
TOTALS	12	14	13	12	20	16
Arrival from 3,500 feet altitude to airport						
(1) Approach for landing to touchdown on runway.	9	11	10	5	7	6
(2) Touchdown to high speed turn-off and taxiing to terminal.	-	-	-	4	6	5
TOTALS	9	11	10	9	13	11

(a) The data are from observations of commercial aircraft (piston powered, gasoline fueled) operations made in January 1961 and confirmed in 1964. Altitudes were established by radio communications with the pilot of the **aircraft.** Ranges of aircraft were established by radar observations in the FAA Control Tower **at** Los Angeles International Airport. Elapsed times were established with stopwatch and coordination of visual, radar, and monitored radio observations.

TABLE XIII

AVERAGE RATE OF AVIATION GASOLINE CONSUMPTION OF PISTON POWERED AIRCRAFT IN VARIOUS OPERATING MODES(a)

NUMBER OF ENGINES	POUNDS(b) OF AVIATION GASOLINE CONSUMED PER MINUTE TAXIING	TAKE-OFF	CLIMB-OUT to 3,500 feet altitude	APPROACH from 3,500 feet
Four	24	160	120	36
Two	6	66	48	14

(a) The average rate of fuel consumption for four engine aircraft and for two engine aircraft are based on data obtained from the Federal Aviation Agency.

(b) Aviation gasoline weighs 5.9 pounds per gallon.

TABLE XIV

AMOUNT OF GASOLINE USED PER AVERAGE FLIGHT(a) BY FOUR ENGINE PISTON POWERED AIRCRAFT IN LOS ANGELES COUNTY

OPERATIONAL MODE	AVERAGE NUMBER OF MINUTES IN MODE(b)	RATE OF FUEL CONSUMPTION IN POUNDS PER MINUTE(c)	POUNDS OF GASOLINE USED
Departure from airport to 3,500 feet altitude			
(1) Taxi from terminal to end of runway and await clearance from traffic control tower.	8	24	192
(2) Take-off.	0.8	160	128
(3) Climb-out to 3,500 feet altitude	6.2	120	744
TOTAL			1,064
Arrival from 3,500 feet altitude to airport			
(1) Approach for landing to touchdown on runway.	6	36	216
(2) Touchdown to high speed turn-off and taxiing to terminal.	4	24	96
TOTAL			312
Total for 1 departure and 1 arrival			1,376
Pounds gasoline per average flight			688(d)

(a) An "average flight" is the arithmetical average of a departure flight and an arrival flight.
(b) Data from Table XI
(c) Data from Table XIII
(d) Fuel usage per average flight in gallons is 688 ÷ 5.9 = 117

TABLE XV

AMOUNT OF GASOLINE USED PER AVERAGE FLIGHT(a) BY TWO ENGINE PISTON POWERED AIRCRAFT IN LOS ANGELES COUNTY

OPERATIONAL MODE	AVERAGE NUMBER OF MINUTES IN MODE(b)	RATE OF FUEL CONSUMPTION IN POUNDS PER MINUTE(c)	POUNDS OF GASOLINE USED
Departure from airport to 3,500 feet altitude			
(1) Taxi from terminal to end of runway and await clearance from traffic control tower.	8	6	48
(2) Take-off.	1	66	66
(3) Climb-out to 3,500 feet altitude	7	48	336
TOTAL			450
Arrival from 3,500 feet altitude to airport			
(1) Approach for landing to touchdown on runway.	6	14	84
(2) Touchdown to high speed turn-off and taxiing to terminal.	5	6	30
TOTAL			114
Total for 1 departure and 1 arrival			564
Pounds gasoline per average flight			282

(a) An "average flight" is the arithmetical average of a departure flight and an arrival flight.
(b) Data from Table XII.
(c) Data from Table XIII.
(d) Fuel usage per average flight in gallons is 282 ÷ 5.9 = 48.

TABLE XVI

AVERAGE RATE OF EMISSION OF AIR CONTAMINANTS FROM PISTON TYPE INTERNAL COMBUSTION ENGINES(a)

	AIR CONTAMINANT					
	HYDROCARBONS	OTHER ORGANIC GASES	PARTICULATE MATTER	OXIDES OF NITROGEN	CARBON MONOXIDE	TOTAL
Pounds per Gallon	0.512	0.009	0.012	0.132	2.789	3.454

(a) From total air pollution data compiled by the Air Pollution Control District of the County of Los Angeles.

TABLE XVII

RATE OF EMISSION OF AIR CONTAMINANTS PER AVERAGE FLIGHT(a) FROM FOUR ENGINE PISTON POWERED AIRCRAFT IN LOS ANGELES COUNTY

GALLONS OF GASOLINE USED PER AVERAGE FLIGHT(b)	AIR CONTAMINANT	AIR CONTAMINANT DATA POUNDS PER GALLON(c)	AIR CONTAMINANT DATA POUNDS PER AVERAGE FLIGHT
117	Hydrocarbons	0.512	59.9
	Other Organic Gases	0.009	1.1
	Particulate Matter	0.012	1.4
	Oxides of Nitrogen	0.132	15.4
	Carbon Monoxide	2.789	326.3
TOTAL		3.454	404.1

(a) An "average flight" is the arithmetical average of a departure flight and an arrival flight.
(b) Data from Table XIV.
(c) Data from Table XVI.

TABLE XVIII

RATE OF EMISSION OF AIR CONTAMINANTS PER AVERAGE FLIGHT(a) FROM TWO ENGINE PISTON POWERED AIRCRAFT, 12,500 POUNDS AND HEAVIER, IN LOS ANGELES COUNTY

GALLONS OF GASOLINE USED PER AVERAGE FLIGHT(b)	AIR CONTAMINANT	AIR CONTAMINANT DATA POUNDS PER GALLON(c)	AIR CONTAMINANT DATA POUNDS PER AVERAGE FLIGHT
48	Hydrocarbons	0.512	24.6
	Other Organic Gases	0.009	0.4
	Particulate Matter	0.012	0.6
	Oxides of Nitrogen	0.132	6.3
	Carbon Monoxide	2.789	133.9
TOTAL		3.454	165.8

(a) An "average flight" is the arithmetical average of a departure flight and an arrival flight.
(b) Data from Table XV.
(c) Data from Table XVI.

TABLE XIX

TIME AND FUEL CONSUMPTION DATA ON SINGLE ENGINE AND TWIN ENGINE (LIGHTER THAN 12,500 POUNDS) PISTON POWERED AIRCRAFT

OPERATIONAL MODE	TIME PER TRIP[a] MINUTES	FUEL CONSUMPTION POUNDS/MINUTE	POUNDS/TRIP
Take-off and Climb-out[b]	6[c]	1.2	7.2
Cruise[d]	48	0.7	33.6
Approach[e]	6	0.3	1.8
TOTAL	60	2.2	42.6(f)

(a) Total time per trip for this type of aircraft will vary from half an hour to an hour and a half.
(b) The rate of climb averages from 500 to 600 feet per minute.
(c) Few of this type aircraft actually climb-out for 6 minutes at a time but many engage in what is known as "touch and go" landings and take-offs. The six minutes represent a cumulative average.
(d) Cruising speed averages 80-150 miles per hour.
(e) Rate of descent varies from 200 to 1,000 feet per minute.
(f) 42.6 pounds of gasoline used per trip divided by 5.9 pounds per gallon equals 7.22 gallons per trip. Each trip represents two flights (an arrival and a departure), so the average consumption of gasoline per average flight is 3.6 gallons.

TABLE XX

RATE OF EMISSION OF AIR CONTAMINANTS FROM SINGLE ENGINE AND LIGHT TWIN ENGINE PISTON POWERED AIRCRAFT IN LOS ANGELES COUNTY

GALLONS OF GASOLINE USED PER AVERAGE FLIGHT(a)	CONTAMINANT	CONTAMINANT DATA EMISSIONS POUNDS PER GALLON(b)	 POUNDS PER FLIGHT
3.6	Hydrocarbons	0.512	1.84
	Other Organic Gases	0.009	0.03
	Particulate Matter	0.012	0.04
	Oxides of Nitrogen	0.132	0.48
	Carbon Monoxide	2.789	10.04
TOTAL		3.454	12.43

(a) Data from Table XIX.
(b) Data from Table XVI.

TABLE XXI

RATE OF EMISSION OF AIR CONTAMINANTS FROM PISTON POWERED HELICOPTERS IN LOS ANGELES COUNTY

GALLONS OF GASOLINE USED PER AVERAGE FLIGHT(a)	CONTAMINANT	CONTAMINANT DATA EMISSIONS POUNDS PER GALLON(b)	 POUNDS PER FLIGHT
18	Hydrocarbons	0.512	9.22
	Other Organic Gases	0.009	0.16
	Particulate Matter	0.012	0.22
	Oxides of Nitrogen	0.132	2.38
	Carbon Monoxide	2.789	50.20
TOTAL		3.454	62.18

(a) An average of 18 gallons of gasoline per flight was arrived at by consultation with Los Angeles Airways Helicopters and the Los Angeles County Sheriff's Office in 1961.
(b) Data from Table XVI.

TABLE XXII

AIR CONTAMINANT EMISSIONS FROM FOUR ENGINE PISTON POWERED AIRCRAFT OPERATED AT LOS ANGELES INTERNATIONAL AIRPORT, 1970

AVERAGE NUMBER OF FLIGHTS PER YEAR(a)	CONTAMINANT	CONTAMINANT DATA		
		POUNDS/FLIGHT(b)	EMISSIONS POUNDS/YEAR	TONS/YEAR
1,825	Hydrocarbons	59.9	109,318	55
	Other Organic Gases	1.1	2,008	1
	Particulate Matter	1.4	2,555	1
	Oxides of Nitrogen	15.4	28,105	14
	Carbon Monoxide	326.3	595,498	298
TOTAL		404.1	737,484	369

(a) From Table I
(b) From Table XVII.

TABLE XXIII

AIR CONTAMINANT EMISSIONS FROM TWO ENGINE PISTON POWERED AIRCRAFT OPERATED AT LOS ANGELES INTERNATIONAL AIRPORT, 1970

AVERAGE NUMBER OF FLIGHTS PER YEAR(a)	CONTAMINANT	CONTAMINANT DATA		
		POUNDS/FLIGHT(b)	EMISSIONS POUNDS/YEAR	TONS/YEAR
58,400	Hydrocarbons	24.6	1,436,640	718
	Other Organic Gases	0.4	23,360	12
	Particulate Matter	0.6	35,040	18
	Oxides of Nitrogen	6.3	367,920	184
	Carbon Monoxide	133.9	7,819,760	3,910
TOTAL		165.8	9,682,720	4,842

(a) From Table I.
(b) From Table XVIII.

TABLE XXIV

AIR CONTAMINANT EMISSIONS FROM SINGLE ENGINE AND TWIN ENGINE (LIGHTER THAN 12,500 POUNDS) PISTON POWERED AIRCRAFT OPERATED AT LOS ANGELES INTERNATIONAL AIRPORT, 1970

AVERAGE NUMBER OF FLIGHTS PER YEAR(a)	CONTAMINANT	CONTAMINANT DATA		
		POUNDS/FLIGHT(b)	EMISSIONS POUNDS/YEAR	TONS/YEAR
78,110	Hydrocarbons	1.84	143,722	72
	Other Organic Gases	0.03	2,343	1
	Particulate Matter	0.04	3,124	2
	Oxides of Nitrogen	0.48	37,493	19
	Carbon Monoxide	10.04	784,224	392
TOTAL		12.43	970,906	486

(a) From Table I.
(b) From Table XX.

TABLE XXV

AIR CONTAMINANT EMISSIONS FROM HELICOPTERS OPERATED AT LOS ANGELES INTERNATIONAL AIRPORT, 1970

AVERAGE NUMBER OF FLIGHTS PER YEAR(a)	CONTAMINANT	CONTAMINANT DATA		
		POUNDS/FLIGHT(b)	EMISSIONS POUNDS/YEAR	TONS/YEAR
8,760	Hydrocarbons	9.22	80,767	40
	Other Organic Gases	0.16	1,402	1
	Particulate Matter	0.22	1,927	1
	Oxides of Nitrogen	2.38	20,849	10
	Carbon Monoxide	50.20	439,752	220
TOTAL		62.18	544,697	272

(a) From Table I.
(b) From Table XXI.

TABLE XXVI

ESTIMATE OF TOTAL QUANTITIES OF AIR POLLUTANTS EMITTED ANNUALLY WITHIN LOS ANGELES COUNTY BY AIR CARRIER AIRCRAFT AND GENERAL AVIATION AIRCRAFT USING THE LOS ANGELES INTERNATIONAL AIRPORT, 1970

(See Table XXIX for the portion of these emissions occurring within LAX boundary)

AIRCRAFT	CONTAMINANTS IN TONS (rounded) PER YEAR					
	PARTICULATE MATTER	CARBON MONOXIDE	OXIDES OF NITROGEN	COMBUSTIBLE ORGANIC GASES	SULFUR DIOXIDE	TOTALS
(1) COMMERCIAL TRANSPORTS						
Turbojet[a]	560	1,360	320	810	170	3,220
Turbofan[b]	3,260	8,960	2,120	17,270	840	32,450
Turboprop[c]	40	8	40	20	10	120
TOTAL	3,860	10,330	2,480	18,100	1,020	35,790
(2) COMMERCIAL TRANSPORTS						
Piston Engine[d]	20	4,430	210	825	--	5,485
(3) PRIVATE AIRCRAFT						
Piston Engine[e]	1	390	19	75	--	485
TOTALS	3,880	15,145	2,705	18,990	1,015	41,760

(a) Turbojets include the following gas turbine engines: JT3C-6 (water injection), JT4A, CJ805-3B, JT3C-7, and Dart-7.
(b) Turbofans include the following gas turbine engines: JT3D, JT8D, JT9D, and CJ805-23.
(c) Turboprops are 501D gas turbine engines.
(d) Piston engine commercial transports include: 4 engine aircraft, 2 engine aircraft 12,500 pounds and heavier, and helicopters.
(e) Piston engine private aircraft include: single engine aircraft and twin engine aircraft lighter than 12,500 pounds.

TABLE XXVII

ADJUSTED (FOR AREA WITHIN LAX BOUNDARIES ONLY) AVERAGE ANNUAL AMOUNT OF AIR CONTAMINANTS IN TONS EMITTED BY GAS TURBINE AIRCRAFT ENGINES OPERATED AT LAX, 1970

ENGINE MODEL NUMBER	NUMBER OF ENGINE FLIGHTS PER YEAR AT LAX[a]	PARTICULATE MATTER ADJUSTED		CARBON MONOXIDE ADJUSTED		OXIDES OF NITROGEN ADJUSTED		COMBUSTIBLE ORGANIC GASES ADJUSTED		SULFUR DIOXIDE ADJUSTED		TOTAL AIR CONTAMINANTS ADJUSTED TONS PER YEAR (rounded)
		POUNDS PER AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	
JT4A	101,984	5.000	255	18.477	940	2.116	110	5.436	275	1.204	60	1,640
JT9D	49,344	4.128	100	14.255	350	3.882	95	4.324	105	1.195	30	680
JT3D	631,232	3.139	990	17.504	5,525	1.387	440	3.905	1,230	0.775	245	8,430
JT8D	488,370	3.094	755	9.391	2,295	1.304	320	35.362	8,635	0.696	170	12,175
JT3C-6	32,120	4.488	70	13.36[illegible]	215	0.927	15	2.070	35	1.198	19	355
CJ805-3B	26,280	3.074	40	1.208	16	1.295	17	9.123	120	0.941	12	205
501D	23,360	2.478	30	0.550	6	2.417	30	1.507	18	0.597	7	90
TOTAL	1,352,690		2,240		9,345		1,025		10,420		545	23,575

(a) From Table II.
(b) An "Average Flight" is the arithmetical average of a departure flight and an arrival flight.

TABLE XXVIII

ADJUSTED (FOR AREA WITHIN LAX BOUNDARIES ONLY) AVERAGE ANNUAL AMOUNT OF AIR CONTAMINANTS IN TONS EMITTED BY COMMERCIAL PISTON POWERED AIRCRAFT OPERATED AT LAX, 1970

TYPE OF PISTON POWERED AIRCRAFT	NUMBER OF FLIGHTS PER YEAR AT LAX[a]	PARTICULATE MATTER ADJUSTED		CARBON MONOXIDE ADJUSTED		OXIDES OF NITROGEN ADJUSTED		COMBUSTIBLE ORGANIC GASES ADJUSTED		TOTAL AIR CONTAMINANTS ADJUSTED
		POUNDS PER AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	POUNDS PER AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	POUNDS PER A AVERAGE FLIGHT[b]	TONS PER YEAR (rounded)	TONS PER YEAR (rounded)
Four Engine	1,825	0.7104	1	165.109	150	7.8144	7	30.843	30	190
Two Engine	58,400	0.2136	6	49.644	1,450	2.3496	70	9.274	270	1,795
Helicopters	8,760	0.011	negligible	2.51	11	0.119	1	0.469	2	14
TOTAL	68,985		7		1,610		80		300	2,000

(a) From Table I.
(b) An "Average Flight" is the arithmetical average of a departure flight and an arrival flight.

TABLE XXIX

ADJUSTED (FOR AREA WITHIN LAX BOUNDARIES ONLY) ESTIMATE OF TOTAL QUANTITIES OF AIR POLLUTANTS EMITTED ANNUALLY AT THE LOS ANGELES INTERNATIONAL AIRPORT FROM AIR CARRIER AIRCRAFT AND GENERAL AVIATION AIRCRAFT DURING 1970

AIRCRAFT	CONTAMINANTS IN TONS (rounded) PER YEAR(a)					
	Particulate Matter	Carbon Monoxide	Oxides of Nitrogen	Combustible Organic Gases	Sulfur Dioxide	TOTALS
(1) COMMERCIAL TRANSPORTS						
Turbojet(b)	365	1,170	140	430	90	2,195
Turbofan(c)	1,845	8,170	855	9,970	445	21,285
Turboprop(d)	30	6	30	18	7	90
TOTAL	2,240	9,345	1,025	10,420	540	23,570
(2) COMMERCIAL TRANSPORTS						
Piston Engine(e)	7	1,610	80	300	-	2,000
(3) PRIVATE AIRCRAFT						
Piston Engine(f)	negligible	20	1	4	-	25
TOTALS	2,250	10,975	1,105	10,725	540	25,595

(a) From Tables XXVII and XXVIII.
(b) Turbojets include the following gas turbine aircraft engines: JT3C-6 (water injection), JT4A, CJ805-3B, JT3C-7, and Dart-7.
(c) Turbofans include the following gas turbine aircraft engines: JT3D, JT8D, JT9D, and CJ805-23.
(d) Turboprops are 501D gas turbine aircraft engines.
(e) Piston engine commercial transports include: 4 engine aircraft, 2 engine aircraft 12,500 pounds and heavier, and helicopters.
(f) Piston engine private aircraft include: single engine aircraft and twin engine aircraft lighter than 12,500 pounds.

TABLE XXX

ESTIMATE OF TOTAL QUANTITIES OF AIR POLLUTANTS EMITTED ANNUALLY AT THE LOS ANGELES INTERNATIONAL AIRPORT FROM GROUND OPERATIONS WITHIN THE AIRPORT BOUNDARIES DURING 1970

GROUND OPERATION SOURCE	CONTAMINANTS IN TONS (rounded) PER YEAR					
	PARTICULATE MATTER	CARBON MONOXIDE	OXIDES OF NITROGEN	COMBUSTIBLE ORGANIC GASES	SULFUR DIOXIDE	TOTALS
(1) Aircraft Fueling Systems(a)	—	—	—	55	—	55
(2) Operation of Service Vehicles(b)	20	4,245	200	905	12	5,380
(3) Aircraft Engine Run-up During Maintenance and Ground-Check(c)	110	510	30	615	25	1,290
(4) Vehicles Entering and Leaving The Airport(d)	40	8,980	600	1,630	30	11,280
(5) Miscellaneous Sources At The Airport(e)	40	1	150	605	135	930
TOTALS	210	13,735	980	3,810	200	18,935

(a) There are 139 aircraft fueling stations within the boundaries of LAX.

(b) There are 1,217 pieces of power operated ground service equipment plus 189 motor vehicles.

(c) An average of 15,330 engines are run-up per year for an average of 25 minutes each.

(d) Some 92,328,000 motor vehicles enter and leave the boundaries of LAX per year. These cars consume 7,590,000 gallons of gasoline per year within the boundaries of LAX.

(e) Miscellaneous sources within the boundaries of LAX consist of: abrasive blast cabinets, baghouses, boilers, degreasers, loading racks, multiple chamber incinerators, paint bake ovens, paint spray booths, floating roof tanks, underground tanks, vapor recovery systems.

TABLE XXXI

ESTIMATE OF TOTAL QUANTITIES OF AIR POLLUTANTS EMITTED ANNUALLY WITHIN THE BOUNDARIES (AND BELOW 3,500 FEET ALTITUDE) OF THE LOS ANGELES INTERNATIONAL AIRPORT DURING 1970

SOURCE	CONTAMINANTS IN TONS (Rounded) PER YEAR						
	Particulate Matter	Carbon Monoxide	Oxides of Nitrogen	Combustible Organic Gases	Sulfur Dioxide	TOTALS Tons	TOTALS Per Cent
Commercial Transports (Turbine) (a)	2,240	9,345	1,025	10,420	540	23,570	53.0
Commercial Transports (Piston) (a)	7	1,610	80	300	-	2,000	4.5
Private Aircraft (Piston) (a)	negligible	20	1	4	-	25	-
Collateral Ground Operations (b)	210	13,735(c)	980	3,810	200	18,935	42.5
TOTALS	2,460	24,710	2,085	14,535	740	44,530	

(a) From Table XXIX.
(b) From Table XXX.
(c) Approximately 65% of this value represents contributions of vehicles entering and leaving the airport.

TABLE XXXII

TONS OF AIR CONTAMINANTS EMITTED PER YEAR WITHIN THE BOUNDARIES OF LAX BY POWER OPERATED, GROUND SERVICE EQUIPMENT, 1970

AIR CONTAMINANT	POUNDS EMITTED PER 1,000 GALLONS GASOLINE USED BY UNCONTROLLED MOTOR VEHICLES	TONS EMITTED PER YEAR (Rounded)
Particulate Matter	13.8	20
Carbon Monoxide	2,783	4,095
Nitrogen Oxides	128.8	190
Combustible Organic Gases	598.8	880
Sulfur Dioxide	7.5	11
TOTAL	3,531.8	5,195

TABLE XXXIII

TONS OF AIR CONTAMINANTS EMITTED PER YEAR WITHIN THE BOUNDARIES OF LAX BY 173 MOTOR VEHICLES EQUIPPED WITH EMISSION CONTROLS AND OPERATED WITHIN THE BOUNDARIES OF LAX, 1970

AIR CONTAMINANT	POUNDS EMITTED PER 1,000 GALLONS GASOLINE USED BY CONTROLLED MOTOR VEHICLES	TONS EMITTED PER YEAR (Rounded)
Particulate Matter	10.5	1
Carbon Monoxide	2,365.5	150
Nitrogen Oxides	157.5	10
Combustible Organic Gases	430	25
Sulfur Dioxide	7.5	1
TOTAL	2,971	185

TABLE XXXIV

TOTAL TIME AND THE PER CENT OF TIME GAS TURBINE AIRCRAFT ENGINES ARE OPERATED IN VARIOUS OPERATIONAL MODES DURING RUN-UP AND MAINTENANCE AT LAX, 1970

AIRLINE TEST FACILITY NUMBER	NUMBER OF ENGINES PER DAY	MINUTES EACH ENGINE IS RUN	TOTAL ENGINE MINUTES PER DAY	PER CENT OF TIME RUN IN EACH OF THE FOLLOWING OPERATIONAL MODES		
				IDLE	CRUISE	FULL POWER
1	4	30	120	75	25	seldom
	2	15	30	75	25	seldom
2	1	2	2	75	25	never
3	8	15	120	75	25	seldom
4	3	30	90	75	25	seldom
	2	15	30	75	25	seldom
5	2	180	360	75	22	3
6	20	15	300	75	25	seldom
TOTAL	42	Ave. 25	1,052	75	25	seldom

TABLE XXXV

TONS OF AIR CONTAMINANTS EMITTED PER YEAR WITHIN THE BOUNDARIES OF LAX BY GAS TURBINE AIRCRAFT ENGINES DURING RUN-UPS AND MAINTENANCE GROUND CHECKS, 1970

AIR CONTAMINANT	IDLE MODE 789 MINUTES/DAY		CRUISE MODE 263 MINUTES/DAY		TOTAL EMISSIONS FROM BOTH MODES	
	POUNDS EMITTED PER ENGINE PER AVE. MINUTE	POUNDS EMITTED PER DAY	POUNDS EMITTED PER ENGINE PER AVE. MINUTE	POUNDS EMITTED PER DAY	POUNDS EMITTED PER DAY	TONS EMITTED PER YEAR
Particulate Matter	0.186	147	0.694	183	330	60
Carbon Monoxide	1.214	958	0.519	136	1,094	200
Nitrogen Oxides	0.040	32	0.334	88	120	22
Combustible Organic Gases	1.015	801	4.332	1,139	1,940	354
Sulfur Dioxide	0.043	34	0.140	37	71	13
TOTAL		1,972		1,583	3,555	649

TABLE XXXVI

TONS OF AIR CONTAMINANTS EMITTED PER YEAR WITHIN THE BOUNDARIES OF LAX BY JET POWERED AIRCRAFT WHILE TAXIING BETWEEN MAINTENANCE AREAS AND SATELLITE TERMINALS, 1970

AIR CONTAMINANT	TAXI MODE 1410 ENGINE MINUTES PER DAY		TONS EMITTED PER YEAR
	POUNDS EMITTED PER MINUTE PER AVE. ENGINE	POUNDS EMITTED PER DAY	
Particulate Matter	0.186	262	48
Carbon Monoxide	1.214	1,712	312
Nitrogen Oxides	0.040	56	10
Combustible Organic Gases	1.015	1,431	261
Sulfur Dioxide	0.043	61	11
TOTAL		3,522	642

TABLE XXXVII

TONS OF AIR CONTAMINANTS EMITTED PER YEAR WITHIN THE BOUNDARIES OF LAX BY GAS TURBINE AIRCRAFT ENGINES DURING RUN-UP AND MAINTENANCE GROUND-CHECKS, AND ALSO WHEN TAXIING BETWEEN MAINTENANCE AREAS AND SATELLITE TERMINALS, 1970

AIR CONTAMINANTS	EMISSIONS IN TONS PER YEAR		
	FROM ENGINE RUN-UP AND GROUND-CHECK	FROM TAXIING TO AND FROM MAINTENANCE AREA	COMBINED TOTAL (rounded)
Particulate Matter	60	48	110
Carbon Monoxide	200	312	510
Nitrogen Oxides	22	10	30
Combustible Organic Gases	354	261	615
Sulfur Dioxide	13	11	25
TOTAL	649	642	1,290

TABLE XXXVIII

MOTOR VEHICLES OPERATING WITHIN THE BOUNDARIES OF LAX AND THE VEHICLE MILES THEY TRAVEL EACH DAY

STREET TRAVELED (Portions within LAX boundaries only)	VEHICLES PER DAY	MILES[a] TRAVELED	VEHICLE MILES/DAY
1. World Way (completely around)	37,000	2.0	74,000
2. Aviation Blvd.	17,700	0.5	8,850
3. Pershing Drive (between Imperial Hwy. and World Way West)	16,200	1.0	16,200
4. World Way West (in and out)	12,600	1.6	20,160
5. Pershing Drive (between World Way West and Sterry St.)	9,100	1.2	10,920
6. Lincoln Blvd. (between 94th St. and Sepulveda Blvd.)	18,200	1.1	20,020
7. Sepulveda Blvd. (between Imperial Hwy. and Century Blvd.)	42,800	1.0	42,800
8. Sepulveda Blvd. (between Lincoln Blvd. and just below 96th St.)	57,000	0.3	17,100
9. 96th Street	11,000	0.7	7,700
10. East Way	8,800	0.2	1,760
11. Interceptor St. (between Sepulveda Blvd. and Lilienthal Ave.)	2,000	0.7	1,400
12. Avion Drive and Private Century Blvd.	12,000	1.8	21,600
SUB TOTALS	244,400		242,510
Add for miscellaneous driving within LAX boundaries (16%-pure guess)			38,800
			281,310
Plus 3.5%[b]	8,554		9,840
GRAND TOTAL	252,954[c]		291,150

(a) Miles were measured to the nearest tenth.
(b) Based on L. A. County population increase 1967-1969.
(c) Annual number of motor vehicles is 92,328,000 (rounded).

TABLE XXXIX

TONS OF AIR CONTAMINANTS EMITTED PER YEAR WITHIN THE BOUNDARIES OF LAX BY MOTOR VEHICLES OPERATED WITHIN THE BOUNDARIES OF LAX, 1970

AIR CONTAMINANT	POUNDS EMITTED PER 1,000 GALLONS GASOLINE(a) USED BY CONTROLLED(b) MOTOR VEHICLES(c)	TONS EMITTED PER YEAR (rounded)
Particulate Matter	10.5	40
Carbon Monoxide	2,365.5	8,980
Nitrogen Oxides	157.5	600
Combustible Organic Gases	430.0	1,630
Sulfur Dioxide	7.5	30
TOTAL	2,971.0	11,280

(a) 7,590,540 gallons of gasoline used per year.
(b) Assumed to have the same degree of control as the motor vehicle population of Los Angeles County as a whole.
(c) 92,328,000 motor vehicles.

TABLE XL

THE NUMBER OF PARKING SPACES AVAILABLE AND THE ESTIMATED NUMBER OF AUTOMOBILES PARKED DAILY AT LAX, 1970

IDENTITY OF PARKING LOT	PARKING SPACES AVAILABLE	AUTOMOBILES PARKED PER DAY(a)
Major Airline Lots	11,720	20,500
Public Pay Lots	9,900	15,350
VSP Lot	2,400	2,400
West Imperial Lots	700	800
Pershing Drive Lots	550	550
U.S. Post Office Lot	570	1,250
TOTAL	25,840	40,850

(a) The average rate of turnover per parking space is 1.6 cars per day.

TABLE XLI

POUNDS OF HYDROCARBONS EMITTED PER DAY WITHIN THE BOUNDARIES OF LAX BY UNDERGROUND STORAGE TANKS WHICH ARE LISTED BY CAPACITY AND TYPE OF MATERIAL STORED, 1970

NUMBER OF TANKS	MATERIAL STORED	RANGE IN SIZE IN GALLONS	COMBINED CAPACITY IN GALLONS	HYDROCARBON VAPOR EMITTED IN POUNDS PER DAY
43	Gasoline	1,000 to 25,000	328,000	160
22	Jet Fuel	15,000 to 50,000	928,000	340
10	Av. Gasoline	6,000 to 39,000	233,000	115
3	Lube Oil	1,000 to 12,000	14,000	negligible
2	Solvent	4,000 to 10,000	14,000	negligible
1	Isopropyl Alc.	5,000	5,000	negligible
1	Slop over	280	280	negligible
TOTAL 82	--	--	1,522,280	615

TABLE XLII

RECAPITULATION OF THE EMISSIONS OF AIR CONTAMINANTS IN TONS PER YEAR FROM MISCELLANEOUS SOURCES WITHIN THE BOUNDARIES OF LAX, 1970

NO.	EQUIPMENT CATEGORY SOURCE	TONS OF AIR CONTAMINANTS EMITTED PER YEAR					
		PARTICULATE MATTER	CARBON MONOXIDE	NITROGEN OXIDES	HYDROCARBONS AND OTHER ORG. GASES	SULFUR DIOXIDE	TOTAL (rounded)
1.	Abrasive Blast Cabinets	0.4	--	--	--	--	--
2.	Baghouses	negligible	--	--	--	--	--
3.	Boilers	37.0	0.3	147.8	5.8	132.2	325
4.	Chrome Plating Tanks	--	--	--	--	--	--
5.	Degreasers	--	--	--	35.6	--	35
6.	Filling Vehicle Tanks	--	--	--	63.0	--	65
7.	Loading Racks	--	--	--	127.0	--	125
8.	Miscellaneous	--	--	--	15.0	--	15
9.	Multiple Chamber Incinerators	0.4	0.3	0.3	0.4	0.3	2
10.	Paint Bake Ovens	--	--	--	3.5	--	4
11.	Paint Spray Booths	--	--	--	141.0	--	140
12.	Tanks-Floating Roof	--	--	--	77.7	--	80
13.	Tanks-Underground	--	--	--	113.0	--	115
14.	Vapor Recovery Systems	--	--	--	25.6	--	25
	TOTALS (rounded)	40	1	150	605	135	930

TABLE XLIII
SUMMARY OF AIR MONITORING DATA
May - October 1970

STA. NO.	LOCATION		CARBON MONOXIDE One-Hour Avg. - ppm -			PARTICULATE MATTER One-Hour Avg. - Km x 10 -			24-Hour Avg. - ug/M³ -		
			--Range--		Arith.	--Range--		Arith.	--Range--		Arith.
			Min.	Max.	Mean	Min.	Max.	Mean	Min.	Max.	Mean
MAY (from 5/10/70)											
204	F.A.A. VOR Site West End	O[a]	1	19	3.0	1	66	8.6			
209	Command Post, East End	O	1	21	3.4	1	84	18.4			
201	Control Tower, Admin. Bldg.	O	1	21	4.8	-	-	-	59	215	104
203	Satellite 2	O	1	15	3.7	1	106	36.2	54	203[b]	119[b]
202	Satellite 2	I[a]	2	35	8.0	1	106	29.7			
208	Satellite 7	O	2	22	5.3	5	122	56.0	100	230	137
207	Satellite 7	I	4	63	11.1	10	103	55.3			
205	Ticketing Bldg., No. 7	O	-	-	-	5	84	39.6			
206	Ticketing Bldg., No. 7	I	5	70	13.6	6	124	46.6			
APCD MONITORING STATIONS											
76	Southwest Coastal (Lennox)	O	2	35	6.2	1	48	12.6			
1	Central (Downtown L.A.)	O	1	35	5.5	4	116	23.3			
JUNE											
204	F.A.A. VOR Site West End	O	1	6	2.2	1	45	7.5			
209	Command Post, East End	O	1	18	3.2	1	60	14.8			
201	Control Tower, Admin. Bldg.	O	2	12	4.6	-	-	-	62	168	110
203	Satellite 2	O	1	26	6.2	2	219	36.2	64	151	114
202	Satellite 2	I	2	79	9.3	1	100	36.5			
208	Satellite 7	O	1	18	4.8	2	117	51.6	102	185	143
207	Satellite 7	I	2	90	11.3	1	183	58.6			
205	Ticketing Bldg., No. 7	O	-	-	-	4	135	41.9			
206	Ticketing Bldg., No. 7	I	2	66	13.3	9	98	48.4			
APCD MONITORING STATIONS											
76	Southwest Coastal (Lennox)	O	2	18	6.2	1	55	11.9			
1	Central (Downtown L.A.)	O	1	24	5.0	5	75	22.5			
JULY											
204	F.A.A. VOR Site West End	O[a]	1	5	1.7	1	50	9.2			
209	Command Post, East End	O	1	8	3.3	1	80	14.3			
201	Control Tower, Admin. Bldg.	O	1	10	4.4	-	-	-	65	180	112
203	Satellite 2	O	1	20	4.6	1	202	36.8	75	168	110
202	Satellite 2	I[a]	2	110	9.8	2	120	42.5			
208	Satellite 7	O	1	24	5.1	3	137	55.2	92	175	134
207	Satellite 7	I	1	75	9.8	4	170	61.9			
205	Ticketing Bldg., No. 7	O	-	-	-	2	90	43.1			
206	Ticketing Bldg., No. 7	1	3	51	13.1	10	112	49.1			
APCD MONITORING STATIONS											
76	Southwest Coastal (Lennox)	O	2	20	6.1	1	64	11.7			
1	Central (Downtown L.A.)	O	2	25	5.0	5	95	29.4			

(a) "O"--Outside; "I"--Inside.

(b) Highest measured value, 586 ugm/M³, is suspect and was disregarded. Next highest value, 203 ugm/M³ probably correct.

TABLE XLIII (cont'd.)
SUMMARY OF AIR MONITORING DATA
May - October 1970

STA. NO.	LOCATION		CARBON MONOXIDE			PARTICULATE MATTER					
			One-Hour Avg. - ppm -			One-Hour Avg. - Km x 10 -			24-Hour Avg. - ug/M^3 -		
			--Range-- Min.	--Range-- Max.	Arith. Mean	--Range-- Min.	--Range-- Max.	Arith. Mean	--Range-- Min.	--Range-- Max.	Arith. Mean.
AUGUST											
204	F.A.A. VOR Site West End	O[a]	1	12	2.2	1	50	11.5			
209	Command Post, East End	O	1	14	3.6	1	84	19.3			
201	Control Tower, Admin. Bldg.	O	1	14	5.1	-	-	-	60	179	108
203	Satellite 2	O	1	29	5.5	1	214	36.7	65	169	116
202	Satellite 2	I[a]	1	141	10.9	2	115	40.7			
208	Satellite 7	O	1	28	5.6	2	140	56.9	91	192	136
207	Satellite 7	I	3	74	10.1	10	135	66.6			
205	Ticketing Bldg., No. 7	O	-	-	-	2	105	46.1			
206	Ticketing Bldg., No. 7	I	3	132	15.8	11	109	53.6			
APCD MONITORING STATIONS											
76	Southwest Coastal (Lennox)	O	2	23	6.6	1	73	14.7			
1	Central (Downtown L.A.)	O	1	27	4.0	2	100	29.7			
SEPTEMBER											
204	F.A.A. VOR Site West End	O	1	18	3.9	1	92	18.3			
209	Command Post, East End	O	1	31	5.0	1	77	23.3			
201	Control Tower, Admin. Bldg.	O	2	27	6.4	-	-	-	55	277	144
203	Satellite 2	O	2	46	7.2	1	172	44.9	67	285	150
202	Satellite 2	I	2	79	10.3	5	110	43.0			
208	Satellite 7	O	2	27	7.0	6	160	63.2	88	303	168
207	Satellite 7	I	3	39	8.2	10	150	58.8			
205	Ticketing Bldg., No. 7	O	-	-	-	1	130	46.1			
206	Ticketing Bldg., No. 7	I	3	86	12.6	4	153	48.3			
APCD MONITORING STATIONS											
76	Southwest Coastal (Lennox)	O	1	41	6.0	2	70	20.2			
1	Central (Downtown L.A.)	O	1	24	4.6	7	96	33.8			
October											
204	F.A.A. VOR Site West End	O[a]	1	23	4.9	1	100	22.5			
209	Command Post, East End	O	1	27	5.9	1	93	23.2			
201	Control Tower, Admin. Bldg.[b]	O	3	24	7.1	1	114	30.4	59	502	146
203	Satellite 2	O	2	40	7.4	4	280	50.8	64	320	155
202	Satellite 2	I[a]	3	68	10.4	5	114	40.2			
208	Satellite 7	O	1	37	7.7	4	180	58.6	98	490	189
207	Satellite 7	I	3	35	8.3	10	118	56.1			
205	Ticketing Bldg., No. 7[b]	O	2	51	18.5	14	140	48.3			
206	Ticketing Bldg., No. 7	I	4	92	15.0	10	100	46.3			
APCD MONITORING STATIONS											
76	Southwest Coastal (Lennox)	O	1	34	6.0	3	78	22/0			
1	Central (Downtown L.A.)	O	1	30	6.0	5	110	32.5			

(a) "O"--Outside; "I"--Inside.
(b) On 10-13-70 the carbon monoxide instrument operating at Station #201 was moved to Station #205 and the Km instrument operating at Station #205 was moved to Station #201.

TABLE XLIV

CONTAMINANT LEVELS - AIRPORT STATIONS
All Hours 0000-2300
June and October 1970

		FREQUENCY DISTRIBUTION, %					Arith.	Stand.
Month	Sta.	10	30	50	70	90	Mean	Dev.
				CO, ppm				
June	201	2	3	4	5	6	4.6	1.4
	202	5	7	8	10	12	9.3	6.4
	203	3	4	5	7	11	6.2	4.3
	204	1	2	2	2	3	2.2	0.9
	206	6	10	13	15	20	13.3	6.5
	207	7	9	10	11	15	11.3	7.2
	208	3	4	5	6	7	4.8	2.0
	209	2	3	3	4	5	3.2	1.2
Oct.	201	4	5	6	7	12	7.1	3.8
	202	5	7	9	11	17	10.4	5.6
	203	3	4	6	8	14	7.4	4.9
	204	2	3	4	6	10	4.9	3.7
	205	6	12	18	24	31	18.5	9.7
	206	8	11	14	17	24	15.0	7.9
	207	5	6	7	8	15	8.3	4.1
	208	4	5	6	8	14	7.7	4.4
	209	2	3	4	6	14	5.9	5.0
				Km x 10				
June	201				NO DATA			
	202	14	25	37	46	58	36.5	17.7
	203	15	26	32	40	56	36.2	24.3
	204	2	4	6	9	15	7.5	6.1
	205	17	31	41	53	65	41.9	18.6
	206	18	38	52	61	72	48.4	19.9
	207	24	50	64	72	81	58.6	22.3
	208	17	40	55	67	80	51.6	23.4
	209	5	10	13	18	26	14.8	9.2
Oct.	201	11	19	25	37	55	30.4	18.3
	202	18	30	40	50	63	40.2	17.3
	203	22	38	49	60	80	50.8	25.2
	204	6	11	16	27	49	22.5	17.4
	205	25	37	48	57	70	48.3	17.9
	206	22	37	47	55	70	46.3	17.5
	207	24	45	60	70	80	56.1	20.7
	208	26	45	60	70	88	58.6	24.1
	209	9	14	20	29	42	23.2	13.4

TABLE XLV

CONTAMINANT LEVELS - AIRPORT STATIONS
Peak Activity Hours 0900-1100
June & October 1970

		FREQUENCY DISTRIBUTION, %					Arith. Mean	Stand. Dev.
Month	Sta.	10	30	50	70	90		
				CO, ppm				
June	201	4	4	4	5	7	4.8	1.1
	202	7	8	9	10	11	9.3	1.9
	203	3	5	6	8	10	6.3	3.1
	204	1	2	2	3	3	2.4	0.9
	205	NO DATA						
	206	10	14	15	17	19	15.3	3.8
	207	7	9	10	12	13	10.4	2.2
	208	4	5	6	6	7	5.8	1.5
	209	2	3	3	4	4	3.3	0.8
Oct.	201	4	6	7	8	11	7.8	3.6
	202	7	9	10	12	18	11.2	4.7
	203	4	5	7	9	12	7.8	4.1
	204	2	4	5	6	10	5.6	3.3
	205	8	16	20	25	27	19.9	6.9
	206	10	12	14	16	19	14.5	4.0
	207	6	7	8	9	15	8.9	3.6
	208	6	6	7	9	13	8.3	3.2
	209	2	3	4	5	9	5.0	3.2
				Km x 10				
June	201	NO DATA						
	202	39	46	50	55	62	50.8	9.5
	203	30	35	39	45	53	39.8	10.2
	204	1	3	5	7	12	5.8	4.1
	205	40	46	55	60	73	54.6	13.0
	206	58	64	68	73	80	69.0	9.4
	207	64	72	77	81	88	75.9	11.8
	208	50	58	66	75	90	67.1	16.3
	209	14	19	22	25	35	23.7	10.7
Oct.	201	17	28	35	47	58	37.9	17.4
	202	35	45	50	57	73	52.9	14.3
	203	29	45	50	60	79	53.6	18.8
	204	7	13	20	30	43	24.7	16.4
	205	38	51	60	68	100	63.7	22.7
	206	40	50	60	69	80	60.0	15.2
	207	55	65	70	77	89	71.9	13.4
	208	54	65	72	82	100	73.6	17.8
	209	13	21	29	34	55	30.7	16.6

TABLE XLVI

CONTAMINANT LEVELS - AIRPORT STATIONS
Low Activity Hours 0200-0400
June and October 1970

		FREQUENCY DISTRIBUTION, %					Arith.	Stand.
Month	Sta.	10	30	50	70	90	Mean	Dev.
				CO, ppm				
June	201	2	3	3	4	5	3.7	1.4
	202	3	5	6	9	15	8.3	7.0
	203	2	3	4	5	9	5.1	3.6
	204	1	2	2	2	4	2.1	0.9
	205				NO DATA			
	206	4	6	8	13	27	12.2	11.2
	207	5	9	13	19	29	15.4	10.1
	208	1	2	3	4	5	3.3	1.6
	209	2	2	3	4	5	3.1	1.2
Oct.	201	3	5	6	8	11	6.9	3.3
	202	4	6	10	14	18	10.9	5.8
	203	3	4	5	9	14	7.0	4.1
	204	2	3	5	8	12	6.0	3.9
	205	3	5	7	9	18	8.2	5.1
	206	5	8	10	18	36	16.2	15.7
	207	4	4	8	11	17	9.2	5.4
	208	2	4	5	8	13	6.3	4.2
	209	1	3	5	10	14	6.8	4.8
				Km x 10				
June	201				NO DATA			
	202	7	10	14	18	23	14.6	5.8
	203	6	10	15	20	30	16.5	9.6
	204	2	4	6	10	16	8.2	6.4
	205	9	13	16	22	34	18.4	8.9
	206	11	13	16	19	26	17.7	7.3
	207	12	18	23	27	38	25.3	15.0
	208	7	12	16	21	35	18.9	11.2
	209	2	5	8	10	15	8.7	6.5
Oct.	201	9	18	22	35	55	28.3	17.6
	202	12	16	20	25	34	22.3	10.6
	203	15	27	40	54	68	40.0	20.0
	204	6	14	25	36	57	27.5	18.5
	205	17	23	29	33	45	29.2	11.4
	206	14	19	24	30	44	26.2	11.6
	207	14	20	24	30	40	25.5	8.8
	208	13	22	27	34	49	29.4	13.1
	209	8	15	23	29	40	23.3	11.9

TABLE XLVII
SUMMARY OF PAIRED DATA
(Total Hours 0000 - 2300)
May - November 1970

		CO					Km x 10				
STA.	LOCATION	ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.	ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR. COEFF.	SAME POPUL.
MAY											
202	I	8.0					29.7				
203	O	3.8	4.3	3.8	.417	No	36.2	-6.5	14.6	.623	No
206	I	N.Data					46.7				
205	O	N.Data					39.6	7.2	11.2	.812	No
207	I	11.2					55.3				
208	O	5.2	5.9	6.2	.078	No	54.9	0.5	16.8	.749	Yes
204	VW	3.0					8.6				
209	DW	3.5	-0.5	1.7	.712	No	18.6	-10.0	10.9	.565	No
JUNE											
202	I	9.3					36.5				
203	O	6.2	3.1	7.9	-.024	No	36.1	0.3	20.4	.562	Yes
206	I	N.D.					48.4				
205	O	N.D.					41.9	6.5	12.7	.784	No
207	I	11.4					58.3				
208	O	4.8	6.5	7.7	-.125	No	51.7	6.6	18.5	.675	No
204	VW	2.1					7.5				
209	DW	3.2	-1.0	1.3	.289	No	14.8	-7.3	10.1	.162	No
JULY											
202	I	9.8					42.4				
203	O	4.6	5.2	9.6	-.034	No	36.8	5.6	20.5	.615	No
206	I	N.D.					49.1				
205	O	N.D.					43.2	5.9	12.2	.809	No
207	I	9.8					62.1				
208	O	5.0	4.8	5.6	.080	No	55.5	6.6	18.9	.721	No
204	VW	1.7					9.2				
209	DW	3.3	-1.7	1.1	.266	No	14.2	-5.0	11.4	.057	No
AUG.											
202	I	10.8					40.7				
203	O	5.5	5.4	9.0	.088	No	36.8	3.9	18.5	.650	No
206	I	N.D.					53.5				
205	O	N.D.					46.1	7.4	13.2	.759	No
207	I	10.2					66.5				
208	O	5.6	4.6	8.3	-.006	No	56.9	9.6	18.3	.743	No
204	VW	2.2					11.5				
209	DW	3.6	-1.4	1.5	.627	No	19.3	-7.8	12.0	.242	No
SEPT.											
202	I	10.1					42.9				
203	O	7.2	2.8	7.0	.343	No	44.9	-2.0	19.8	.556	1% Poss.
206	I	N.D.					48.3				
205	O	N.D.					46.1	2.2	15.3	.669	No
207	I	8.2					58.8				
208	O	7.0	1.2	4.4	.462	No	63.2	-4.5	17.0	.769	No
204	VW	3.8					18.3				
209	DW	5.0	-1.1	2.8	.707	No	23.2	-4.9	13.6	.554	No

(cont'd)

TABLE XLVII (cont'd.)

		CO					Km x 10				
STA.	LOCATION	ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.	ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR. COEFF.	SAME POPUL.
OCT.											
202	I	10.4					40.2				
203	O	7.6	2.7	4.6	.638	No	50.8	-10.6	21.8	.523	No
206	I	16.3					46.5				
205	O	18.4	-2.1	11.0	.275	No	48.3	-1.8	13.4	.719	Yes
207	I	8.3					56.3				
208	O	7.7	0.6	3.5	.653	No	58.7	-2.5	16.9	.726	No
204	VW	4.9					23.2				
209	DW	6.0	-1.1	3.4	.732	No	23.2	-0.1	11.7	.765	Yes
NOV.											
202	I	9.8					37.4				
203	O	7.1	2.7	3.1	.713	No	46.6	-9.3	20.2	.381	No
206	I	15.9					N.D.				
205	O	18.4	-2.5	8.1	.462	No	N.D.				
207	I	8.7					43.5				
208	O	7.5	1.2	3.5	.595	No	47.4	-3.9	14.4	.718	No
204	VW	5.1					21.4				
209	DW	6.1	-0.9	2.0	.833	No	23.3	-1.9	11.5	.708	2% Poss.

I = Inside
O = Outside
VW = Upwind of Airport (West)
DW = Downwind of Airport (East)

*Value of Correlation Coefficient at 95% Significance Level

May	.088
June through October	.078
November	.138

TABLE XLVIII
SUMMARY OF PAIRED DATA
(Peak Hours 0900 - 1100)
May - November 1970

	CO					Km x 10				
STA.	ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.	ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.
MAY										
202	8.2					43.9				
203	4.0	4.2	1.5	.507	No	44.5	-0.5	15.8	.363	Yes
206	N.D.					65.6				
205	N.D.					49.7	15.9	12.8	.576	No
207	10.4					75.9				
208	6.1	4.3	2.1	.284	No	68.7	7.2	14.0	.444	No
204	2.9					7.1				
209	3.6	-0.7	1.6	-.061	.4% Poss.	28.2	-21.0	9.8	.689	No
JUNE										
202	9.4					50.8				
203	6.2	3.2	3.6	.074	No	39.8	11.0	12.7	.181	No
206	N.D.					69.0				
205	N.D.					54.6	14.4	11.0	.563	No
207	10.4					75.8				
208	5.8	4.6	2.8	-.085	No	67.2	8.6	18.9	.120	No
204	2.3					5.8				
209	3.3	-1.1	1.1	-.040	No	23.8	-18.0	11.4	.023	No
JULY										
202	9.0					57.0				
203	5.5	3.4	3.1	.078	No	42.1	14.9	15.6	.455	No
206	N.D.					70.2				
205	N.D.					55.2	15.1	12.9	.541	No
207	10.2					82.7				
208	6.6	3.6	3.0	.353	No	77.5	5.1	17.8	.074	1% Poss.
204	2.3					9.3				
209	3.6	-1.3	1.1	.220	No	25.5	-16.2	11.4	.036	No
AUG.										
202	10.6					54.2				
203	6.4	4.3	2.7	.367	No	41.2	13.0	11.9	.517	No
206	N.D.					75.5				
205	N.D.					58.9	16.6	11.3	.429	No
207	9.3					90.3				
208	7.1	2.1	2.7	.332	No	79.0	11.2	17.4	.210	No
204	3.1					10.6				
209	3.8	-0.7	1.2	.522	No	31.5	-20.9	11.4	.162	No
SEPT.										
202	10.6					56.1				
203	7.9	2.7	5.3	.328	No	49.7	6.4	12.9	.516	No
206	N.D.					63.7				
205	N.D.					54.6	9.1	15.3	.528	No
207	8.0					77.0				
208	7.5	0.5	2.5	.552	8% Poss.	83.8	-6.8	19.0	.345	.1% Poss.
204	4.8					19.1				
209	4.2	0.6	2.0	.467	1% Poss.	32.6	-13.5	15.6	.448	No

(cont'd)

TABLE XLVIII (cont'd.)

STA.	CO ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.	Km x 10 ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.
OCT.										
202	11.2					52.7				
203	8.2	3.0	2.4	.858	No	53.6	-0.9	14.5	.653	Yes
206	15.0					62.4				
205	19.6	-4.6	6.9	.030	No	63.7	-1.3	24.2	.253	Yes
207	8.9					71.9				
208	8.3	0.7	2.5	.728	1% Poss.	73.7	-1.7	15.9	.517	Yes
204	5.5					25.2				
209	5.0	0.5	2.4	.712	5% Poss.	30.4	-5.2	14.0	.670	.2% Poss.
NOV.										
202	11.7					43.4				
203	8.7	3.0	2.0	.886	No	52.5	-9.1	22.2	.125	5% Poss.
206	17.0					N.D.				
205	20.0	-3.0	6.1	.559	3% Poss.	N.D.				
207	10.3					54.1				
208	9.1	1.2	1.7	.915	No	58.9	-4.8	10.7	.772	4% Poss.
204	6.7					28.5				
209	6.0	0.8	1.3	.922	.9% Poss.	29.9	-1.4	12.2	.697	Yes

*Value of Correlation Coefficient at 95% Significance Level

May	.25
June through October	.21
November	.36

TABLE XLIX
SUMMARY OF PAIRED DATA
(Low Hours 0200 - 0400)
May - November 1970

STA.	CO ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.	Km x 10 ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.
MAY										
202	7.9					12.0				
203	3.4	4.5	4.5	.624	No	18.1	-6.1	9.4	.651	No
206	N.D.					19.7				
205	N.D.					19.8	-0.2	7.0	.680	Yes
207	14.2					22.4				
208	4.1	10.0	8.2	.153	No	22.2	0.2	9.2	.646	Yes
204	3.5					11.3				
209	4.0	-0.6	2.0	.871	4% Poss.	14.3	-3.0	6.5	.839	.1% Poss.
JUNE										
202	8.4					14.6				
203	5.1	3.4	8.3	-.114	.1% Poss.	16.5	-1.9	9.1	.381	6% Poss.
206	N.D.					17.7				
205	N.D.					18.4	-0.7	8.9	.414	Yes
207	15.4					25.2				
208	3.3	12.1	10.1	.032	No	18.9	6.3	15.4	.345	No
204	2.1					8.2				
209	3.1	-1.1	1.2	.394	No	8.7	-0.5	6.2	.545	Yes
JULY										
202	13.8					17.2				
203	3.4	10.4	17.3	.048	No	19.9	-2.7	11.5	.512	3% Poss.
206	N.D.					17.3				
205	N.D.					19.0	-1.6	9.0	.140	9% Poss.
207	9.5					20.2				
208	2.9	6.6	7.2	.081	No	17.0	3.2	10.4	.100	1% Poss.
204	1.4					9.0				
209	3.0	-1.5	1.0	.144	No	7.4	1.6	6.2	.292	2% Poss.
AUG.										
202	11.5					18.7				
203	4.6	6.8	12.4	.099	No	16.6	2.1	11.8	.435	10% Poss.
206	N.D.					25.4				
205	N.D.					23.9	1.5	14.5	.246	Yes
207	12.5					27.6				
208	3.6	9.0	12.6	.056	No	20.6	6.9	16.8	.190	No
204	2.0					11.5				
209	3.7	-1.7	1.4	.824	No	12.5	-1.1	5.7	.776	10% Poss.
SEPT.										
202	11.1					21.4				
203	6.5	4.7	7.8	.507	No	30.9	-9.5	12.4	.710	No
206	N.D.					23.8				
205	N.D.					28.8	-4.9	11.8	-.168	No
207	10.8					25.9				
208	6.0	4.8	6.6	.342	No	28.6	-2.7	8.9	.782	.8% Poss.
204	4.5					19.0				
209	6.0	-1.5	3.3	.708	No	19.2	-0.2	11.2	.640	Yes

(cont'd.)

TABLE XLIX (cont'd.)

	CO					Km x 10				
STA.	ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* CCEFF.	SAME POPUL.	ARITH. MEAN	MEAN DIFF.	STANDARD DEV/DIFF.	CORR.* COEFF.	SAME POPUL.
OCT.										
202	10.9					22.4				
203	7.3	3.6	5.3	.487	No	40.0	-17.6	17.8	.456	No
206	18.0					25.4				
205	8.2	9.7	17.0	.376	No	29.2	-3.8	8.5	.702	1% Poss.
207	9.2					25.6				
208	6.4	2.8	4.3	.622	No	29.1	-3.5	7.5	.832	No
204	6.0					29.1				
209	6.8	-0.8	2.6	.835	1% Poss.	23.8	5.3	10.0	.877	No
NOV.										
202	10.1					26.5				
203	6.1	4.0	5.3	.534	No	35.1	-8.6	13.9	.449	.4% Poss.
206	13.1					N.D.				
205	8.0	5.1	7.8	.141	.3% Poss.	N.D.				
207	10.4					20.5				
208	5.8	4.6	6.0	.388	No	21.7	-1.2	8.4	.677	Yes
204	5.9					23.8				
209	6.8	-0.9	1.5	.904	.8% Poss.	23.0	0.8	11.2	.629	Yes

*Value of Correlation Coefficient at 95% Significance Level

May	.25
June through October	.21
November	.36

TABLE L
EQUATIONS FOR LINE OF BEST FIT - CO
Airport Stations
May - November 1970

STATIONS	TOTAL HOURS	HIGH HOURS	LOW HOURS
202 & 203			
M	Y = 2.26 + 0.19X	Y = 1.09 + 0.36X	Y = 1.54 + 0.24 X
J	6.38 - 0.02X *	5.07 + 0.12X *	5.56 = 0.06 X *
J	4.65 - 0.01X *	4.79 + 0.08X *	3.37 + 0.004X *
A	5.17 + 0.03X	0.96 + 0.51X	4.40 + 0.02 X *
S	5.14 + 0.21X	5.55 + 0.22X	3.96 + 0.23 X
O	1.64 + 0.58X	-0.53 + 0.78X	3.44 + 0.35 X
N	0.35 + 0.69X	-1.22 + 0.85X	3.52 + 0.26 X
206 & 205			
M	-	-	-
J	-	-	-
J	-	-	-
A	-	-	-
S	-	-	-
O	Y = 13.3 + 0.31X	Y = 18.4 + 0.08X *	Y = 6.33+ 0.11 X
N	7.16 + 0.71X	5.48 + 0.86X	7.17+ 0.06 X *
207 & 208			
M	Y = 4.84 + 0.04X *	Y = 3.19 + 0.28X	Y = 3.38 + 0.05 X *
J	5.21 - 0.03X	6.39 - 0.06X *	3.27 + 0.01 X *
J	4.66 + 0.03X	4.28 + 0.23X	2.76 + 0.01 X *
A	5.59 - 0.002X *	3.52 + 0.39X	3.44 + 0.01 X *
S	3.45 + 0.43X	2.74 + 0.60X	3.48 + 0.23 X
O	1.80 + 0.71X	2.37 + 0.66X	1.92 + 0.48 X
N	1.71 + 0.67X	1.07 + 0.78X	3.88 + 0.19 X
204 & 209			
M	Y = 0.81 + 0.91X	Y = 3.74 - 0.06X *	Y = -0.69 + 1.36X
J	2.32 + 0.40X	3.42 - 0.04X *	1.97 + 0.56X
J	2.70 + 0.37X	2.98 + 0.28X	2.67 + 0.21X *
A	1.96 + 0.75X	2.70 + 0.36X	1.38 + 1.13X
S	0.81 + 1.08X	2.57 + 0.33X	0.94 + 1.13X
O	1.13 + 0.99X	1.20 + 0.69X	0.56 + 1.04X
N	1.42 + 0.90X	-0.21 + 0.92X	1.74 + 0.84X

*Correlation coefficient not statistically significant. Equation has no real meaning.

TABLE L (cont'd.)
EQUATIONS FOR LINE OF BEST FIT - Km x 10
Airport Stations
May - November 1970

STATIONS	TOTAL HOURS	HIGH HOURS	LOW HOURS
202 & 203			
M	Y = 14.7 + 0.72 X	Y = 30.3 + 0.32 X	Y = 7.0 + 0.93 X
J	8.1 + 0.77 X	29.9 + 0.19 X *	7.4 + 0.63 X
J	3.0 + 0.80 X	5.7 + 0.64 X	2.8 + 0.99 X
A	1.5 + 0.87 X	8.1 + 0.61 X	7.0 + 0.51 X
S	13.6 + 0.73 X	16.8 + 0.59 X	5.1 + 1.21 X
O	20.0 + 0.77 X	8.2 + 0.86 X	20.7 + 0.86 X
N	26.4 + 0.54 X	43.5 + 0.21 X *	21.0 + 0.53 X
206 & 205			
M	Y = 8.2 + 0.67 X	Y = 21.8 + 0.43 X	Y = 4.7 + 0.77 X
J	6.4 + 0.73 X	1.1 + 0.78 X	9.4 + 0.51 X
J	11.5 + 0.64 X	10.5 + 0.64 X	15.4 + 0.20 X *
A	10.9 + 0.66 X	22.4 + 0.48 X	19.5 + 0.17 X
S	12.9 + 0.68 X	20.8 + 0.53 X	- 0.2 + 1.21 X
O	14.8 + 0.72 X	41.9 + 0.34 X *	9.9 + 0.76 X
N	-	-	-
207 & 208			
M	Y = 5.6 + 0.89 X	Y = 22.3 + 0.61 X	Y = 2.1 + 0.90 X
J	10.6 + 0.70 X	54.7 + 0.17 X *	12.4 + 0.26 X
J	10.9 + 0.72 X	68.5 + 0.11 X *	15.2 + 0.09 X *
A	7.3 + 0.74 X	50.3 + 0.32 X *	17.5 + 0.11 X *
S	7.9 + 0.94 X	50.1 + 0.44 X	- 0.1 + 1.11 X
O	10.7 + 0.85 X	23.5 + 0.70 X	- 2.5 + 1.24 X
N	13.7 + 0.78 X	20.6 + 0.71 X	4.6 + 0.84 X
204 & 209			
M	Y = 11.8 + 0.78 X	Y = 17.6 + 1.48 X	Y = 3.4 + 0.96 X
J	13.0 + 0.24 X	23.4 + 0.06 X *	4.2 + 0.54 X
J	13.3 + 0.10 X *	24.9 + 0.07 X *	5.1 + 0.26 X
A	14.9 + 0.39 X	27.7 + 0.36 X *	2.6 + 0.86 X
S	14.4 + 0.48 X	24.1 + 0.44 X	7.2 + 0.63 X
O	9.7 + 0.58 X	13.4 + 0.67 X	7.3 + 0.57 X
N	12.4 + 0.51 X	13.2 + 0.59 X	11.0 + 0.50 X

*Correlation coefficient not statistically significant. Equation has no real meaning.

TABLE LI

PARTICULATES (ug/m^3) HI VOL SAMPLING - AIRPORT STATIONS
June and October 1970
(Total Hours 0000-2300)

Month	Sta.	FREQUENCY DISTRIBUTION, % 10	30	50	70	90	Arith. Mean	Stand. Dev.
June	201	76	93	106	123	150	110.2	26.9
	203	87	102	113	126	147	113.9	24.1
	208	115	130	142	153	173	142.8	22.9
Oct.	201	68	97	125	161	231	146.5	85.3
	203	77	100	143	168	266	154.7	65.9
	208	110	145	175	210	278	189.0	79.3

TABLE LII
MOBILE LABORATORY SAMPLING SCHEDULE(1)
May - November 1970

SITE NO.	DATE		SITE NO.	DATE		SITE NO.	DATE	
1	6/25 8/26 8/27	9/18* 10/23*	16	6/12* 7/31* 8/1	9/13* 11/4	29	6/2 7/8 8/28*	9/15 9/16
3	6/19* 7/16 7/17*	8/18 10/30*	17	7/2 7/19* 7/20	8/10 9/30	30	6/10 6/11 7/21	8/17 9/26
6	5/28 5/29* 9/10	10/16* 10/21	18	6/16 7/22 8/31	9/1 10/1	31	5/24* 5/25 7/9	8/29 10/7
8	6/1 7/3* 8/5	8/6 9/11*	20	6/7 6/18 6/22	8/14* 9/23	33	6/8 6/26* 9/7	9/8 10/9*
10	7/27 7/28 9/2	10/29 11/5	22	5/18 5/19 6/21*	8/16* 10/2*	36	6/5* 6/6 7/23	9/9 9/17
11	5/11 5/12 7/24*	8/13 9/25*	23	5/26 7/10* 9/4*	10/19 10/20	38	5/22* 7/30 8/19	10/11* 10/12*
12	5/20 6/23 6/24	9/3 9/14 10/28	24	7/4 8/20 8/21*	9/24 10/24	39	6/3 8/3 9/28	9/29 11/2
13	6/15 8/24 10/5	10/6 10/26	25	6/9 7/6 7/7	8/7* 10/13	41	5/27 7/29 8/25	9/21 9/22
15	5/21 6/30 7/1	8/4 10/14 11/3	27	8/11 8/12 10/22	10/27			

(1) All sampling done for 6-hour period 0600-1100 hours standard time, except on Friday or Sunday, designated by asterisk (*) above, when sampling was performed 1300-1800 hours standard time.

TABLE LIII

MOBILE LAB SAMPLING SUMMARY
May to November 1970
(One-Hour Average)

STA. NO.	Direct. and miles from Admin. Bldg.		CARBON MONOXIDE, ppm Range Min.	Max.	Arith. Mean	PARTICULATES, Km x 10 Range Min.	Max.	Arith. Mean
1	NW	2.2	1	7	4.5	2	34	14.7
3	NNE	1.9	1	11	5.0	5	67	23.3
6	N	1.4	3	9	5.7	5	47	18.2
8	NE	2.2	4	8	5.5	12	45	27.3
10	WNW	3.0	2	12	4.5	8	50	23.5
11	WNW	1.9	1	7	3.4	5	47	20.2
12	NW	1.4	3	12	5.3	7	50	24.1
13	NE	1.5	3	17	8.2	22	58	37.7
15	ENE	2.2	2	13	5.7	12	60	32.7
16	W	2.5	2	6	3.7	2	45	13.1
17	WNW	2.3	1	18	5.4	4	110	24.3
18	NNE	0.4	6	25	11.4	18	94	43.7
20	ENE	1.2	4	19	8.8	13	62	33.6
22	ENE	2.1	3	16	7.7	18	73	36.0
23	WSW	1.5	2	7	3.8	5	45	18.3
24	E	1.1	2	9	5.7	5	55	21.1
25	E	1.6	2	10	5.4	17	93	39.4
27	SW	1.0	1	13	6.4	9	68	35.3
29	ESE	1.3	7	20	11.2	16	80	43.2
30	ESE	2.2	4	27	8.6	2	76	22.3
31	SW	2.2	3	7	5.1	2	22	6.8
33	S	1.2	2	8	5.0	3	24	11.4
36	SSW	2.1	3	10	6.1	2	40	13.0
38	SSE	2.2	3	12	5.8	2	51	18.1
39	NE	3.4	1	17	7.5	15	70	41.1
41	E	3.1	2	21	7.8	18	97	46.4
"LAX"a)	S	0.2	1	19	4.4	3	80	43.9
Sta. 76b)	ESE	1.7	1	19	5.5	1	59	15.0

a) Parking site for Mobile Lab when not sampling at other locations. Located near airport Fire Station. Data is average of 38 days of sampling during same hours established for other sites, i.e. 0600-1100 hours except on Friday and Sunday, when sampling was done during 1300-1800 hours.

b) Data for same dates and hours of Mobile Lab sampling at "LAX" location.

TABLE LIV

SUMMARY OF METEOROLOGICAL DATA
L. A. AIRPORT

(June - October 1970)

MONTH	INVERSION BASE HEIGHT, FT. --- Frequency Distribution, %1) ---					Average Temperature,2) F	Average Rel. Humidity,2) %
	10	30	50	70	90		
June	900	1400	2000	2700	4200	66.8	73.3
July	300	800	1200	1400	1900	70.0	73.7
August	300	800	1100	1400	1800	70.6	72.9
September	100	100	1100	1700	3000	70.7	63.4
October	100	500	1800	3300	5000	66.8	63.3

1) Percentage of number of days per month on which the height of the inversion base was equal to or lower than the given value (to the nearest 100 feet).

2) 0600 through 1900.

TABLE LV
WIND DIRECTION AND SPEED
Los Angeles International Airport
May - November 1970

WIND DIRECTION	PERCENT OF TOTAL TIME WIND FROM EACH DIRECTION BY MONTH						
	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER
N	1.8	0.8	0.9	4.6	2.4	2.7	4.1
NNE	1.1	0.7	0.4	0.7	2.9	2.8	3.5
NE	1.2	1.3	0.4	0.8	2.8	4.5	3.8
ENE	3.2	1.5	0.4	1.5	3.6	4.1	4.2
E	7.4	5.6	1.9	3.7	7.0	9.1	17.2
ESE	4.7	4.0	1.9	2.0	4.9	5.4	10.3
SE	3.5	4.9	2.6	2.4	3.1	2.8	4.8
SSE	2.7	4.0	1.5	1.5	2.2	1.8	3.2
S	3.8	4.0	4.2	2.8	4.7	4.0	2.7
SSW	1.4	2.1	1.1	1.1	1.5	1.8	2.3
SW	7.8	9.7	6.8	7.4	4.2	4.3	4.5
WSW	36.1	34.4	40.7	24.7	22.5	17.6	13.2
W	22.2	23.2	29.8	39.7	30.9	30.9	21.4
WNW	0.7	1.9	3.3	3.4	2.9	4.1	1.8
NW	1.6	1.1	2.3	3.4	2.1	2.6	1.8
NNW	0.7	0.7	1.9	1.4	1.8	1.6	0.8
AVG. WIND SPEED (M.P.H.)	8.9	9.1	8.8	8.6	8.3	8.2	8.1

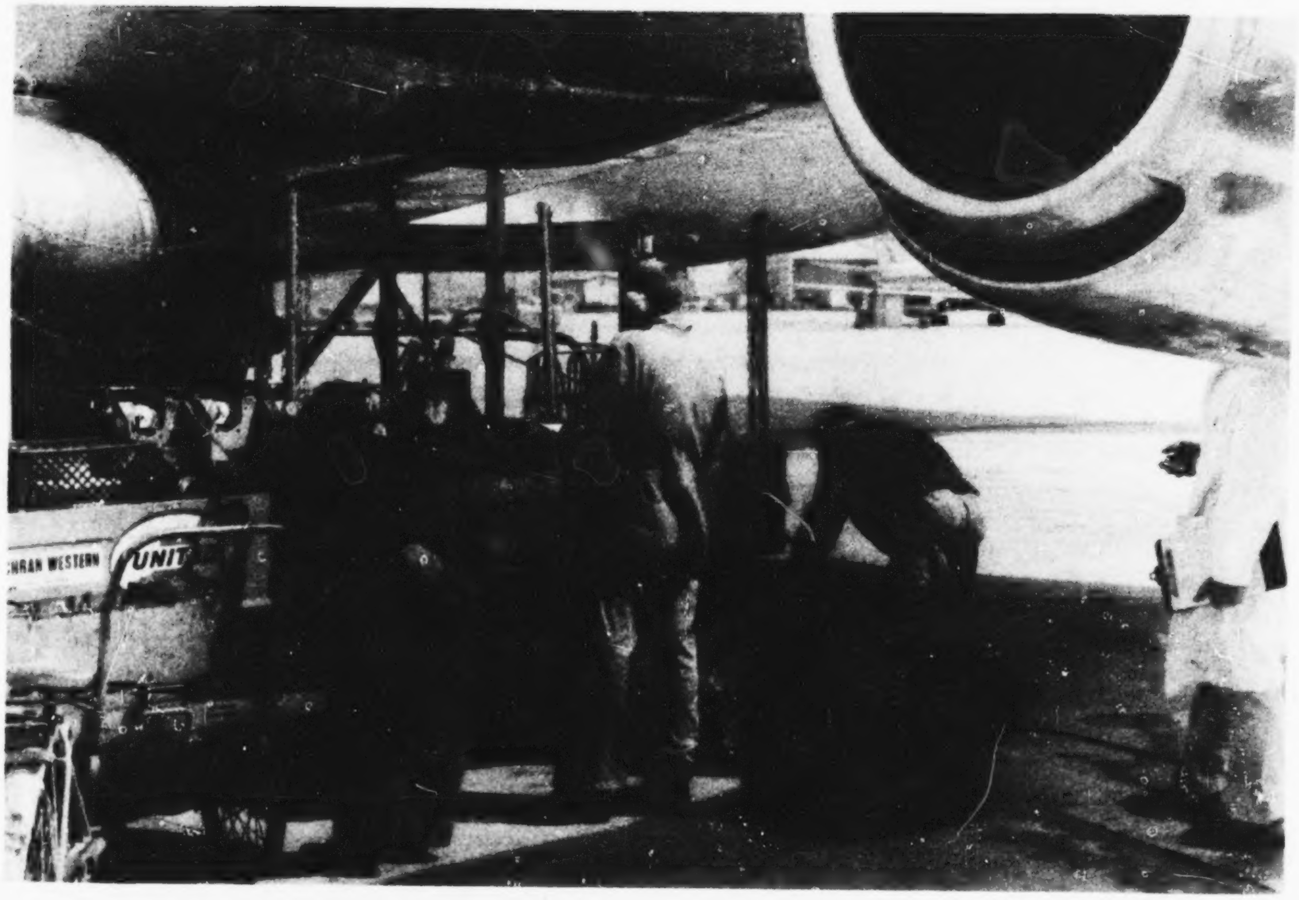


Figure 1. Sampling the exhaust of the No. 2 inboard JT4A turbojet gas turbine aircraft engine mounted on a United Air Lines DC-8. The sampling procedure required from 5 to 9 minutes for each simulated operating mode.

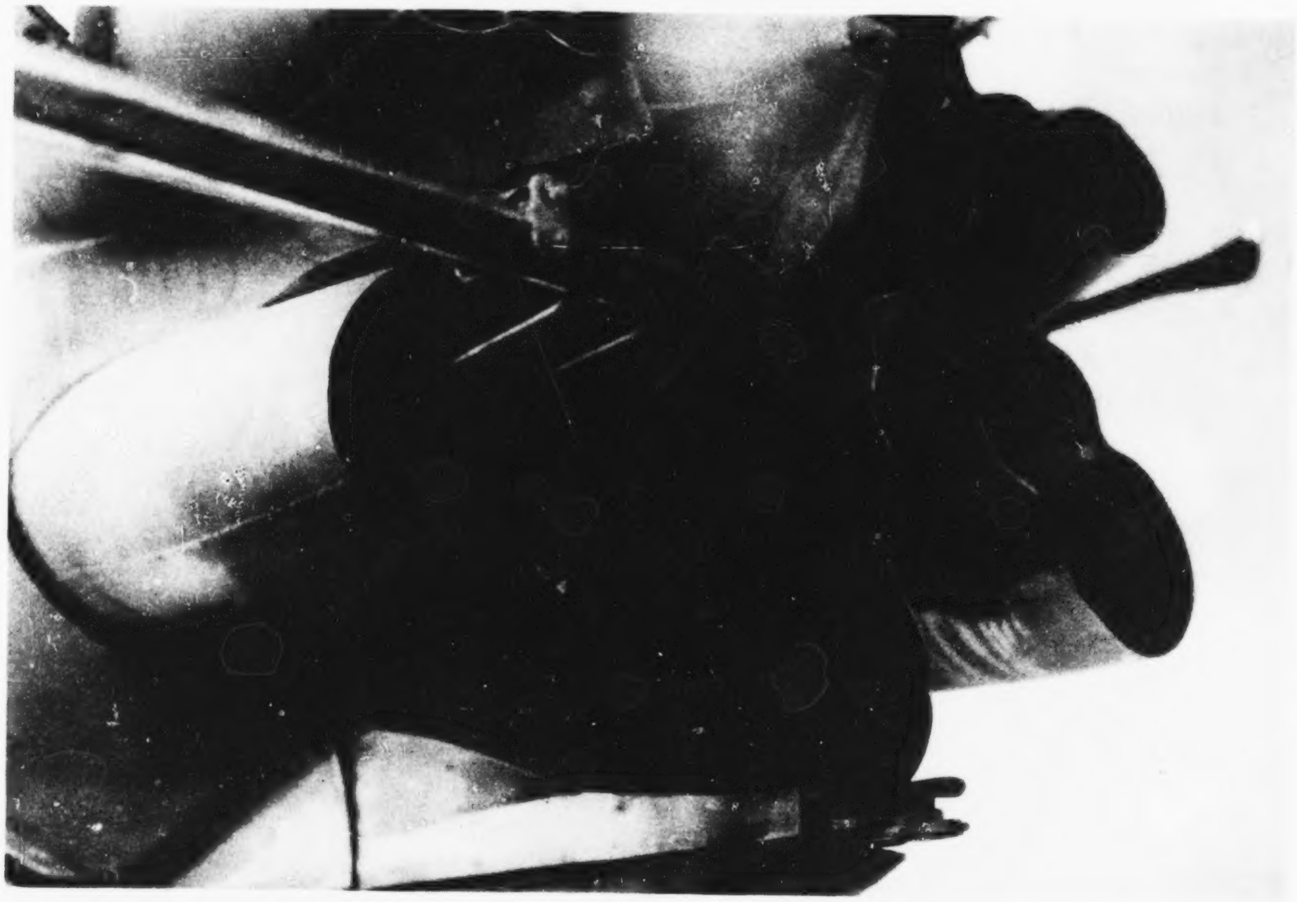


Figure 2. Position of sample probes, pitot tube, and thermocouple when sampling the exhaust from a JT4A turbojet gas turbine aircraft engine mounted on a United Air Lines DC-8.

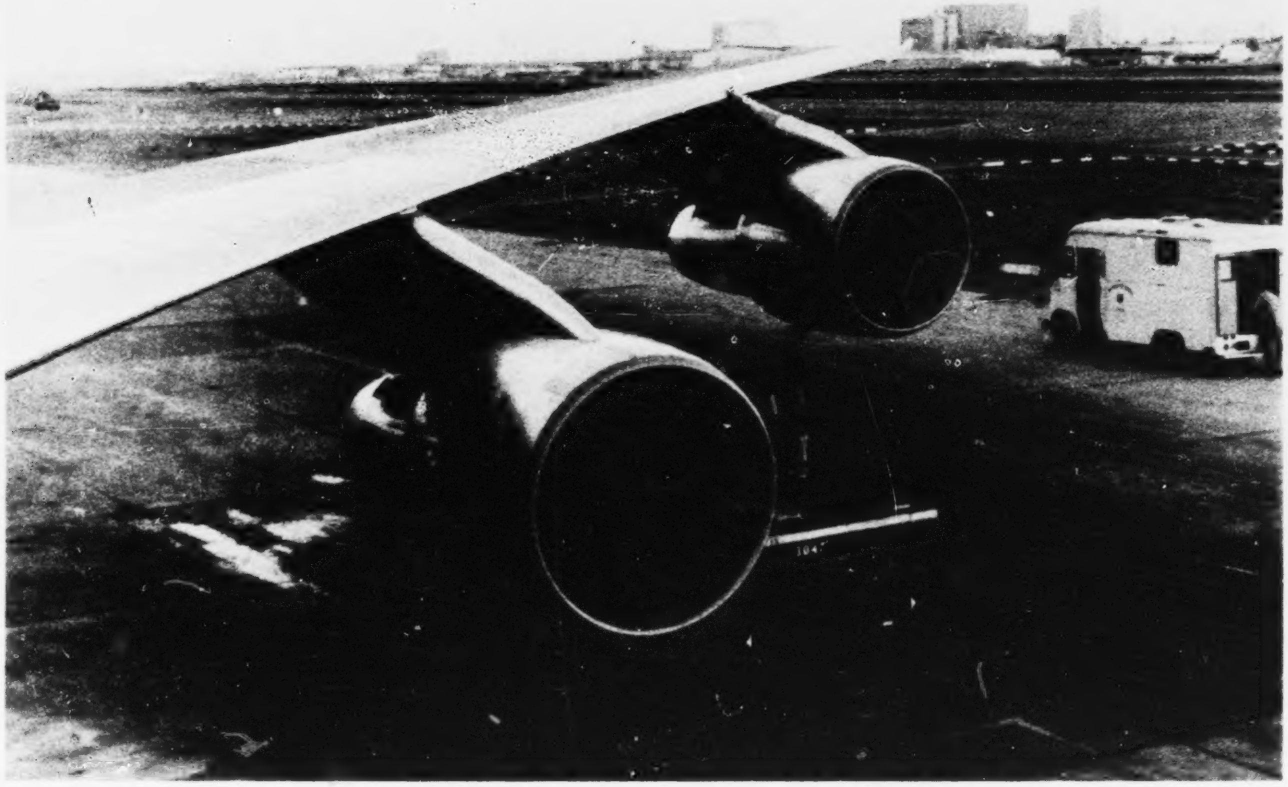


Figure 3. View from the front passenger cabin doorway of the JT9D turbofan gas turbine aircraft engines mounted on an American Airlines 747 aircraft. The scissors manlift upon which the sampling equipment is placed is shown in position alongside the No. 2 inboard engine.

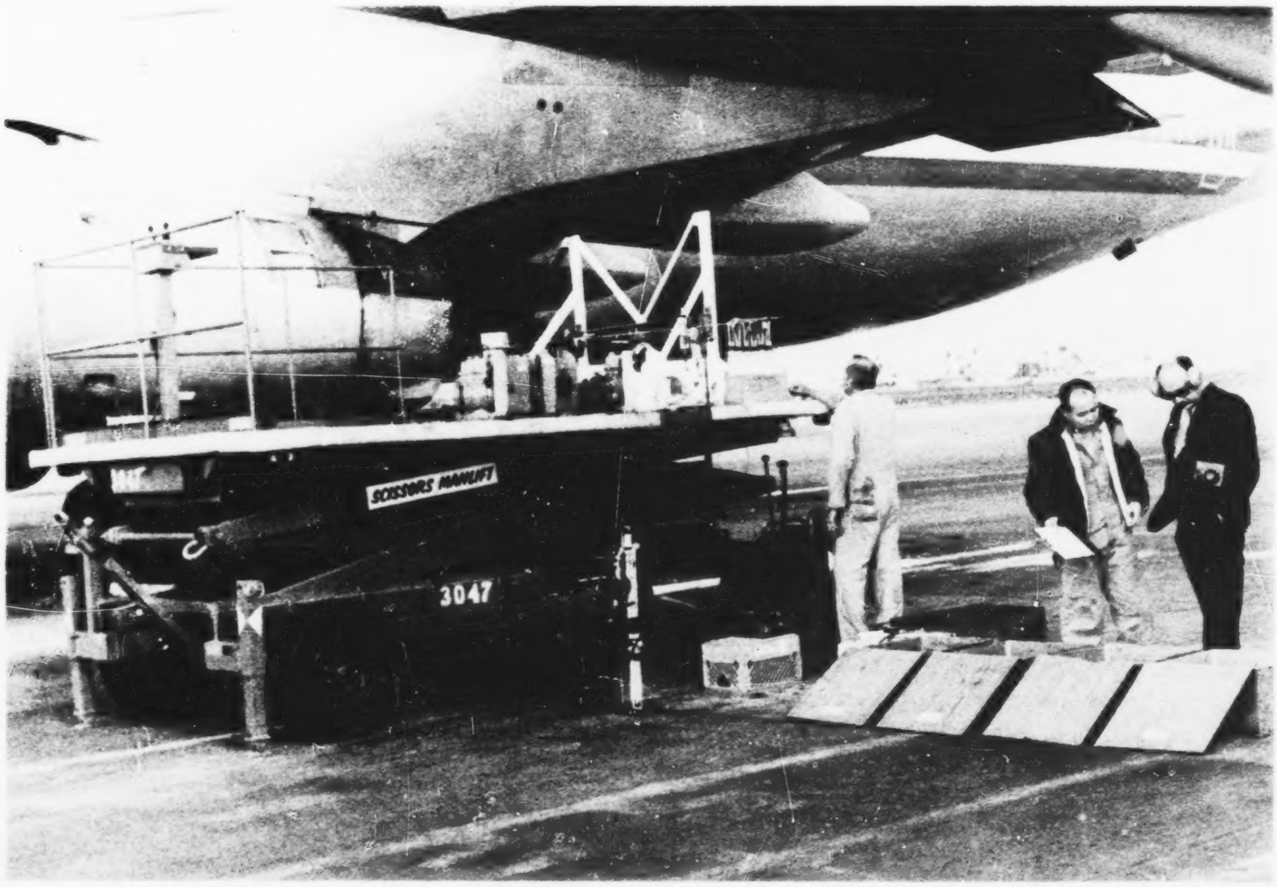


Figure 4. General view of the sampling equipment used for testing exhaust emissions from the JT9D turbofan gas turbine aircraft engine mounted on an American Airlines 747 aircraft.

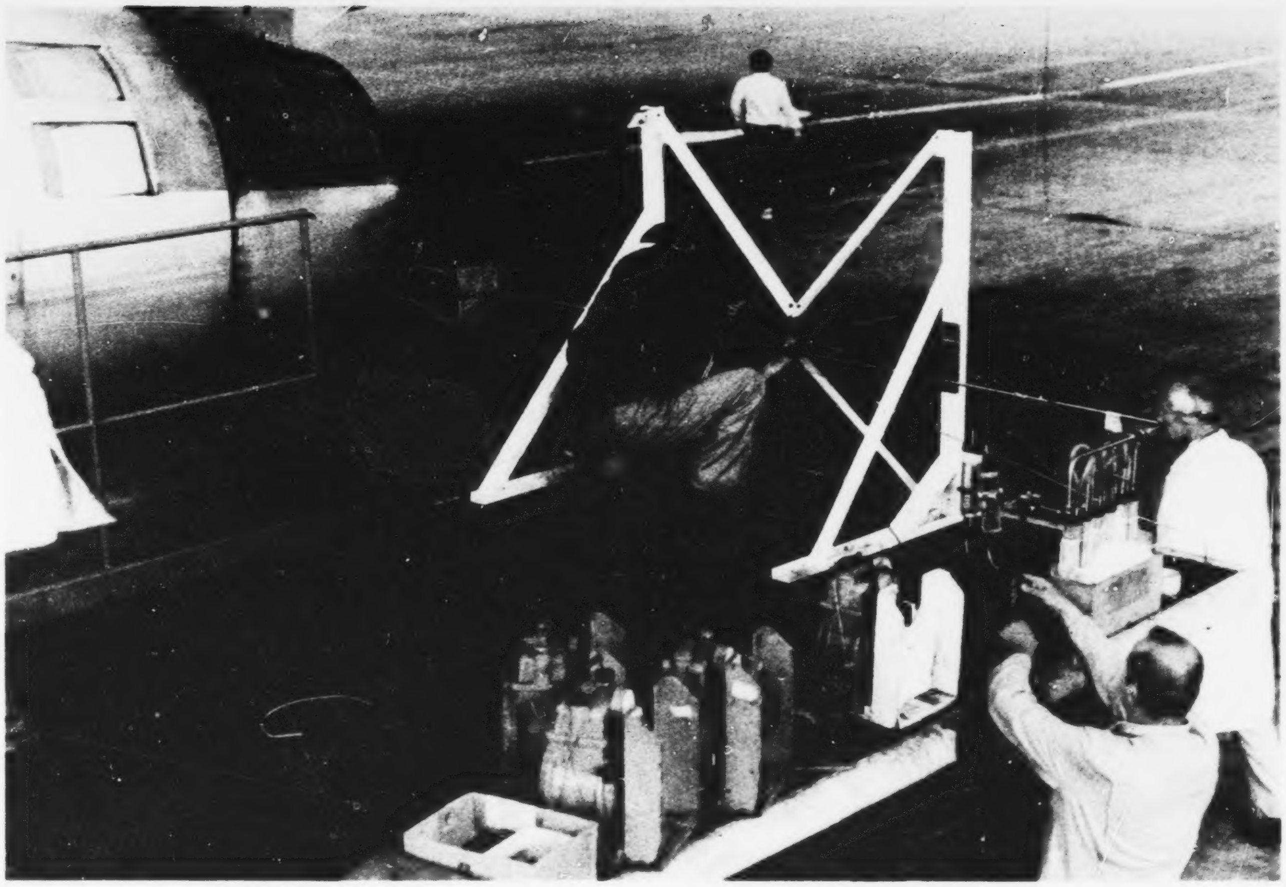


Figure 5. Installing sampling probes, pitot tube, and thermocouple on a specially constructed frame mounted on a mobile scissors manlift truck.

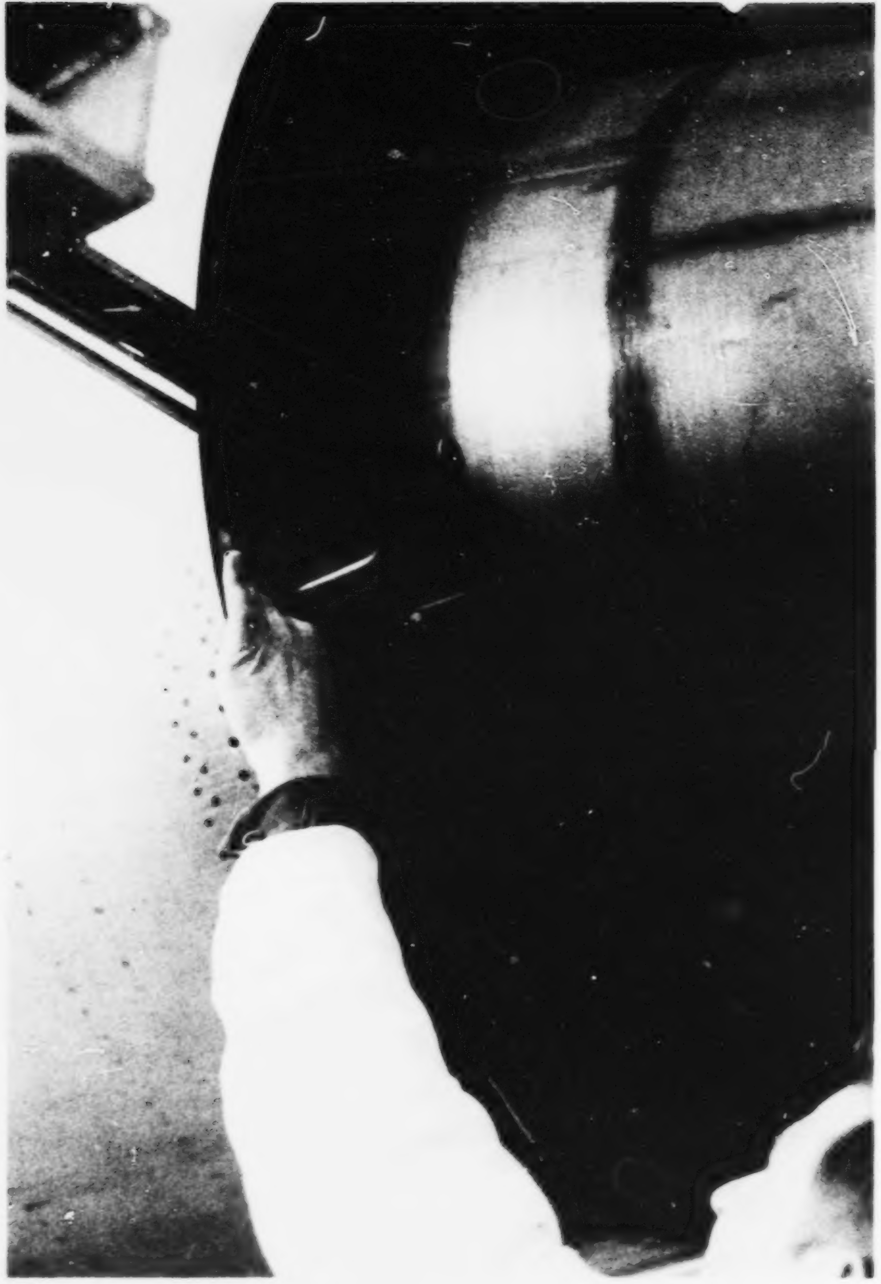


Figure 6. Adjusting the position of the sampling probes, pitot tube, and thermocouple for sampling exhaust from a JT9D turbofan gas turbine aircraft engine mounted on an American Airlines 747 aircraft.

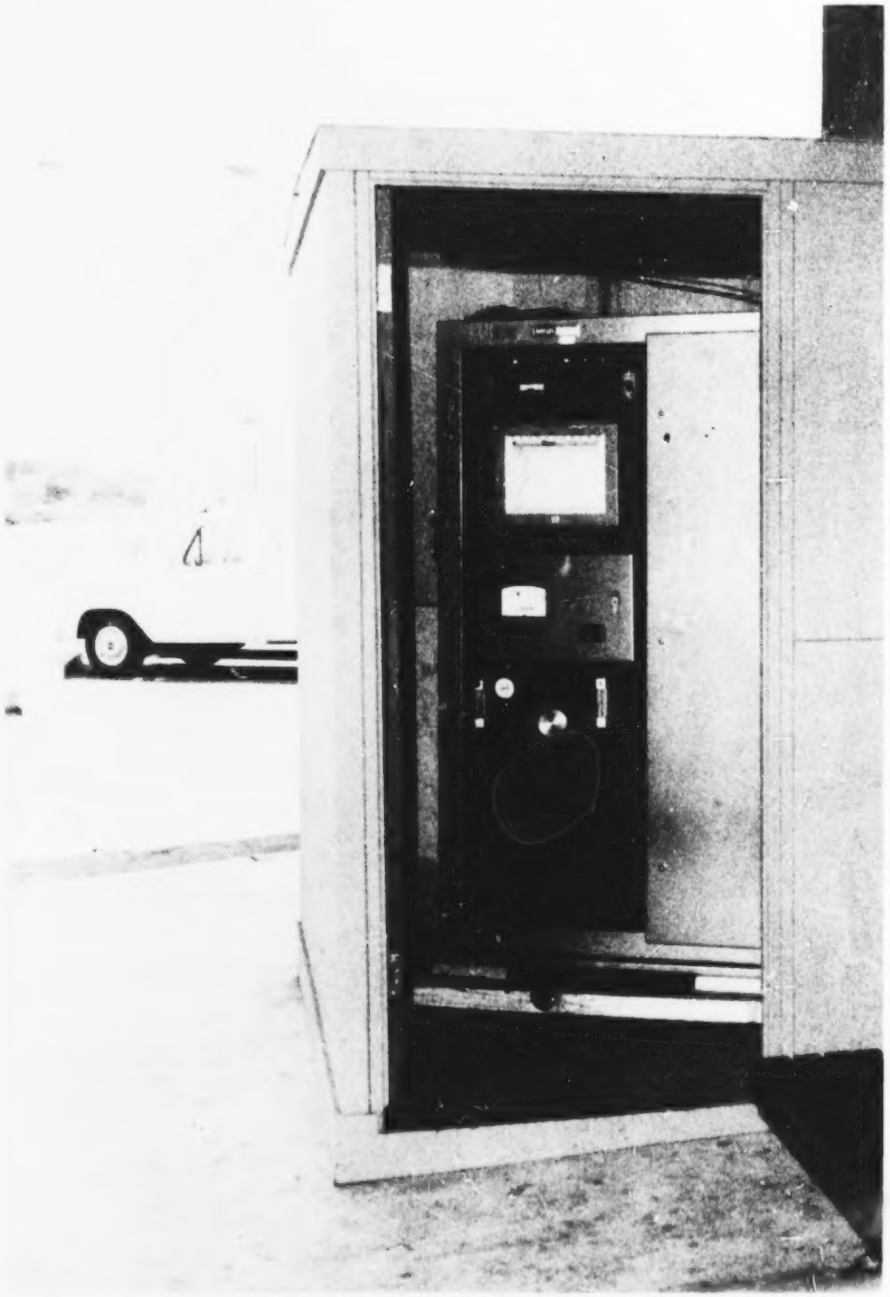


Figure 7. Inside view of sampling station No. 205, outside of Ticketing Building No. 7, showing carbon monoxide recording chart above the MSA Lira infrared analyzer. The tracing seen on the recorder shows the morning CO peak.

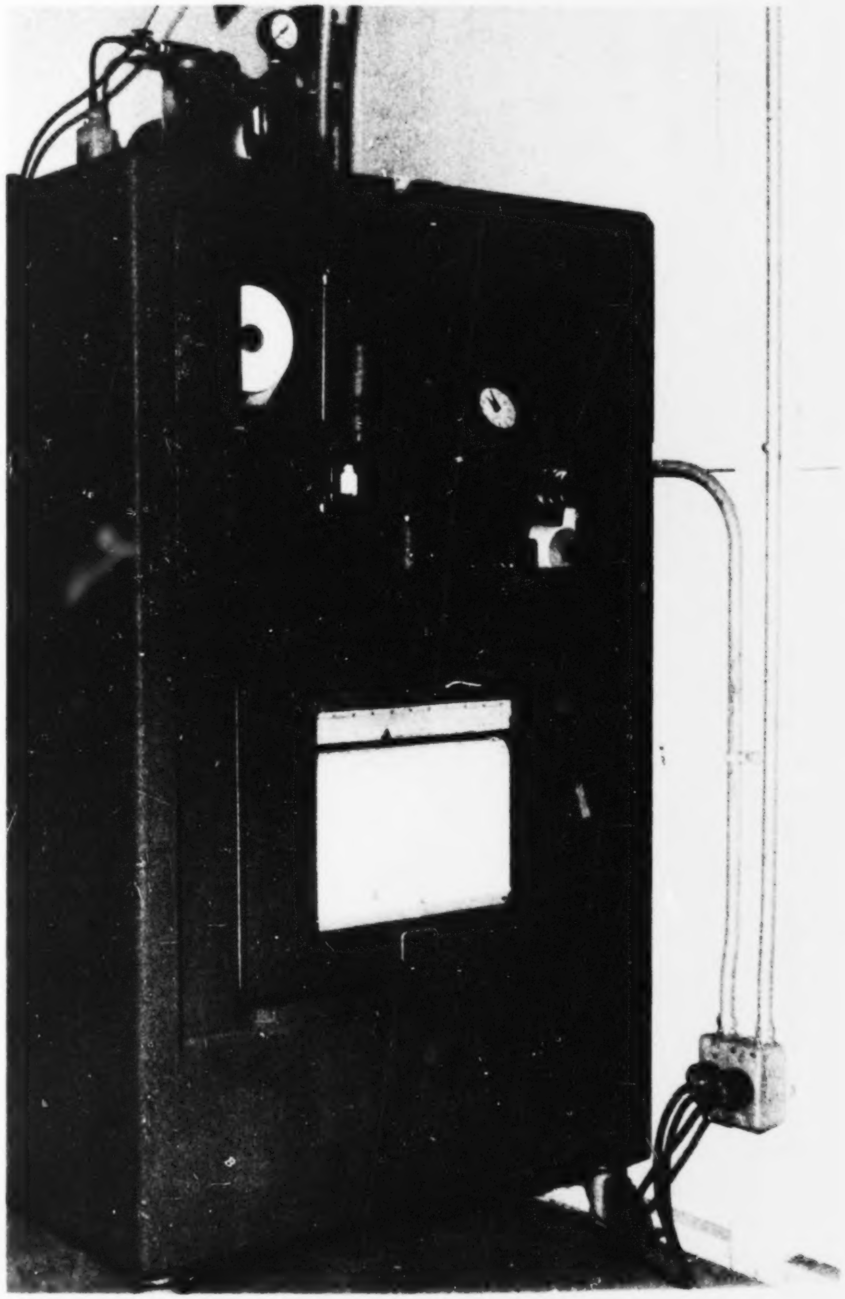


Figure 8. Interior view of sampling station No. 208, outside Satellite No. 7, showing Km sampler and recorder for particulate matter.

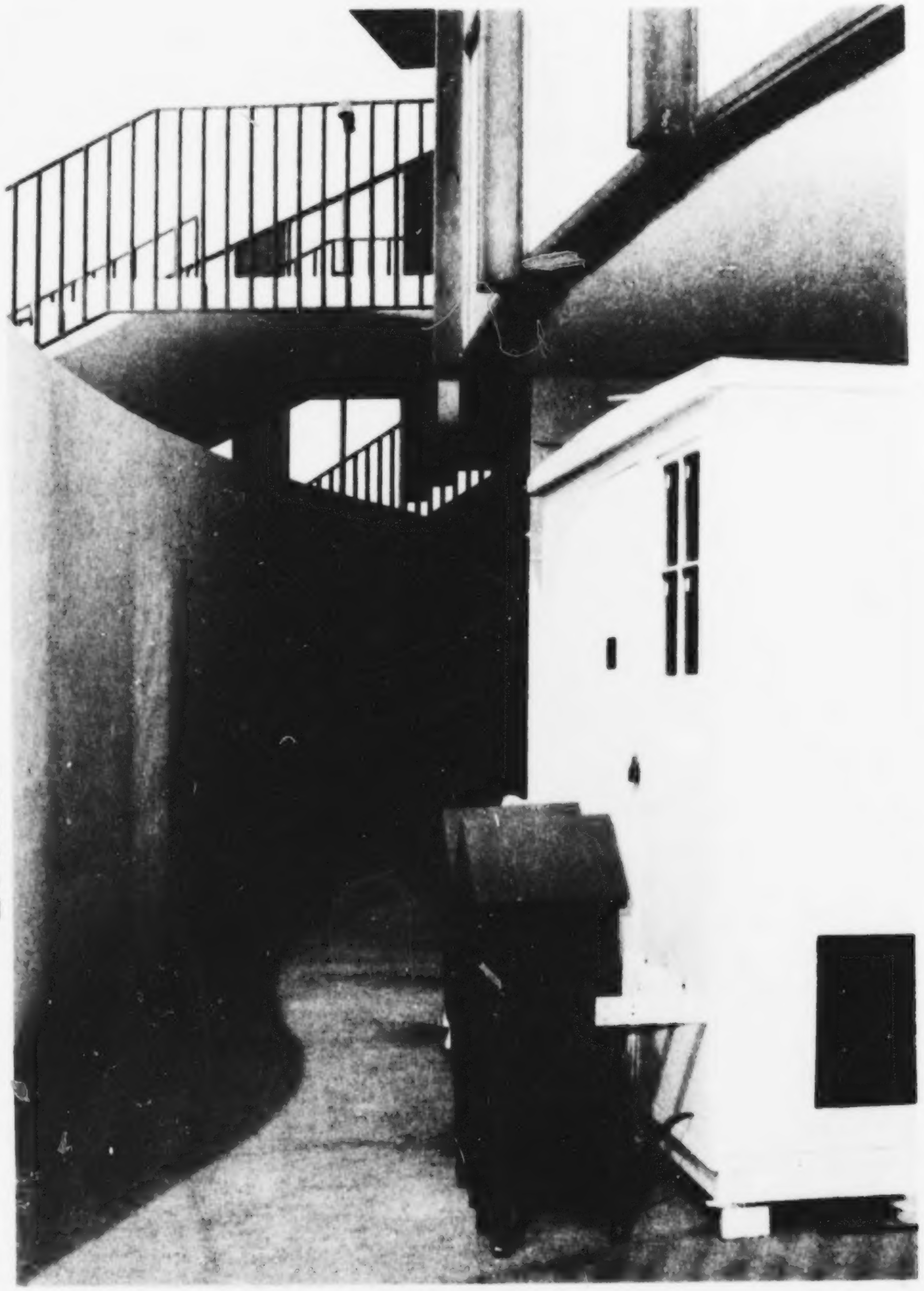


Figure 9. Sampling station No. 203, outside Satellite No. 2, showing Hi-Vol particulate matter samplers.

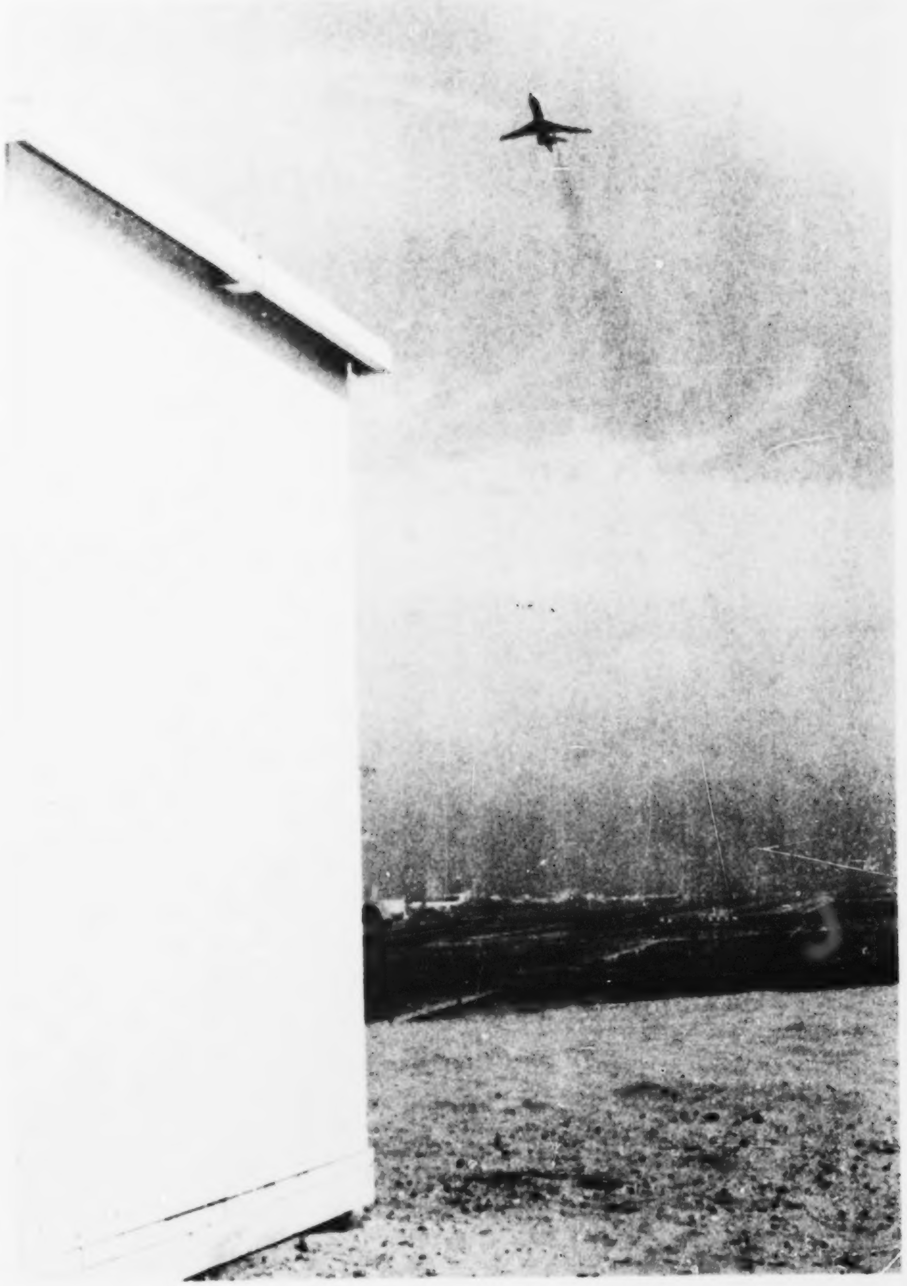


Figure 10. View of exhaust plume from a jet aircraft during ascent. This view was taken from station No. 204 at the VOR site showing proximity to the end of the south take-off runways. Photograph shows the reduced visibility looking ENE.

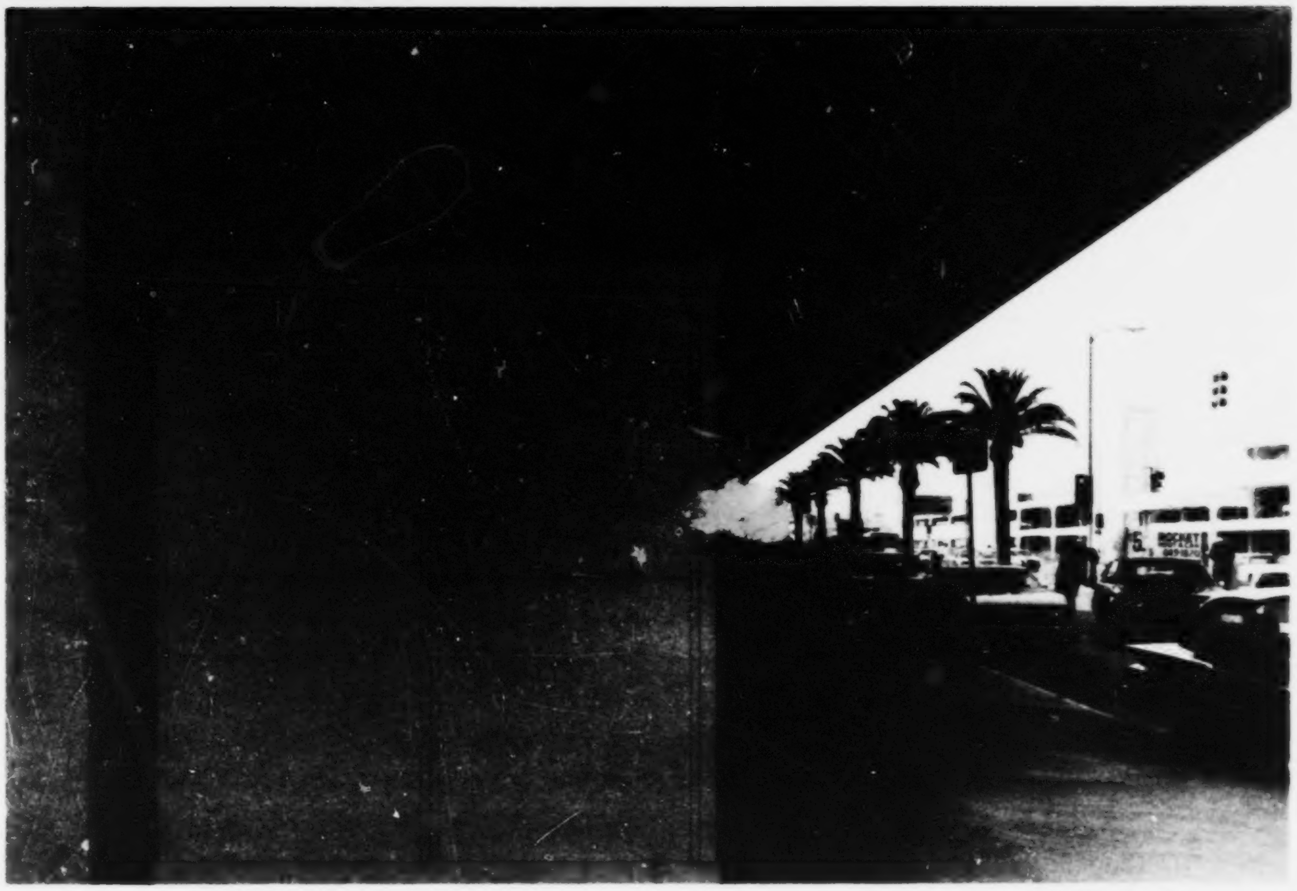


Figure 11. Sampling station No. 205, outside of Ticketing Building No. 7, showing heavy vehicular traffic on World Way.

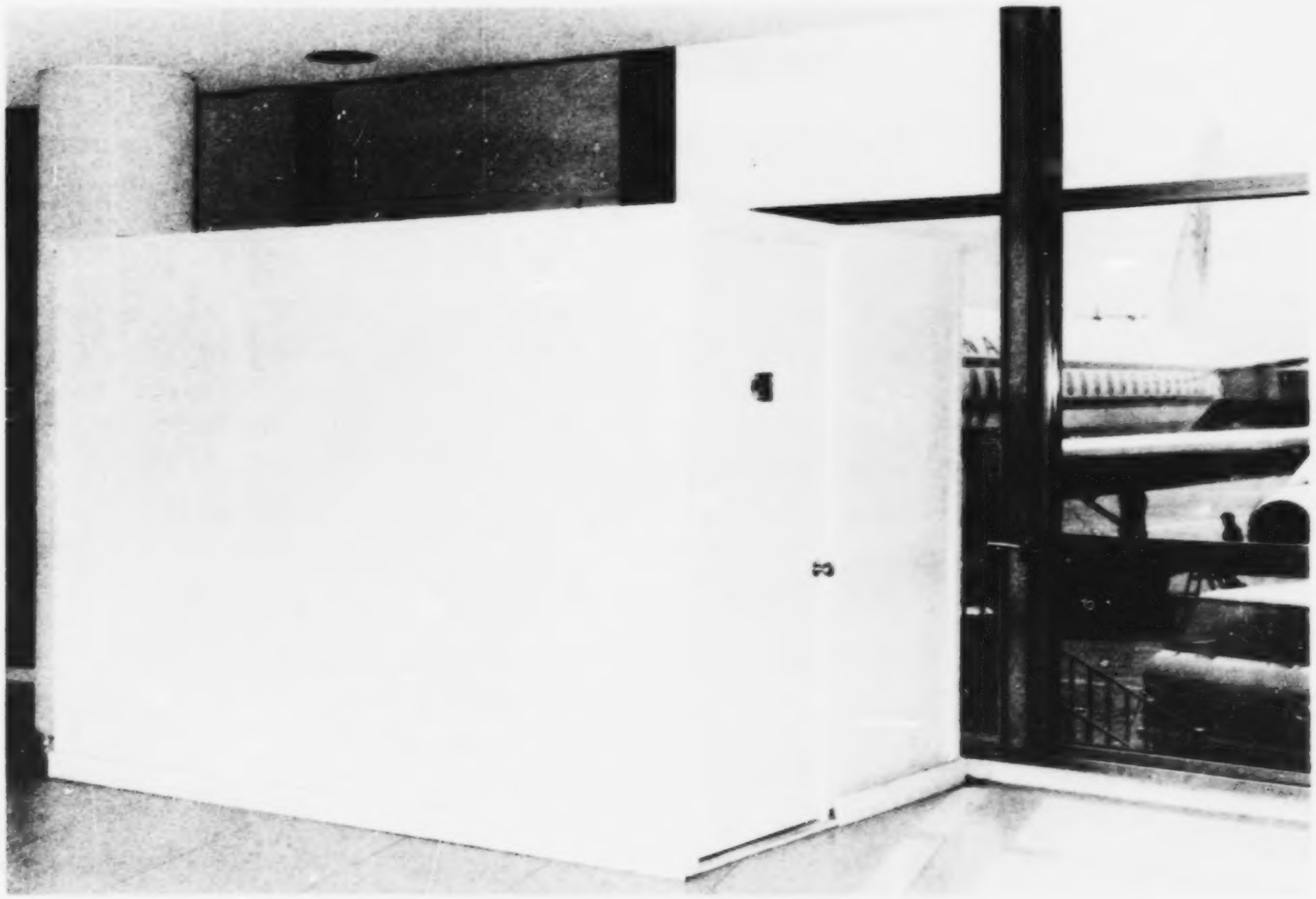


Figure 12. Sampling station No. 202, inside Satellite No. 2.

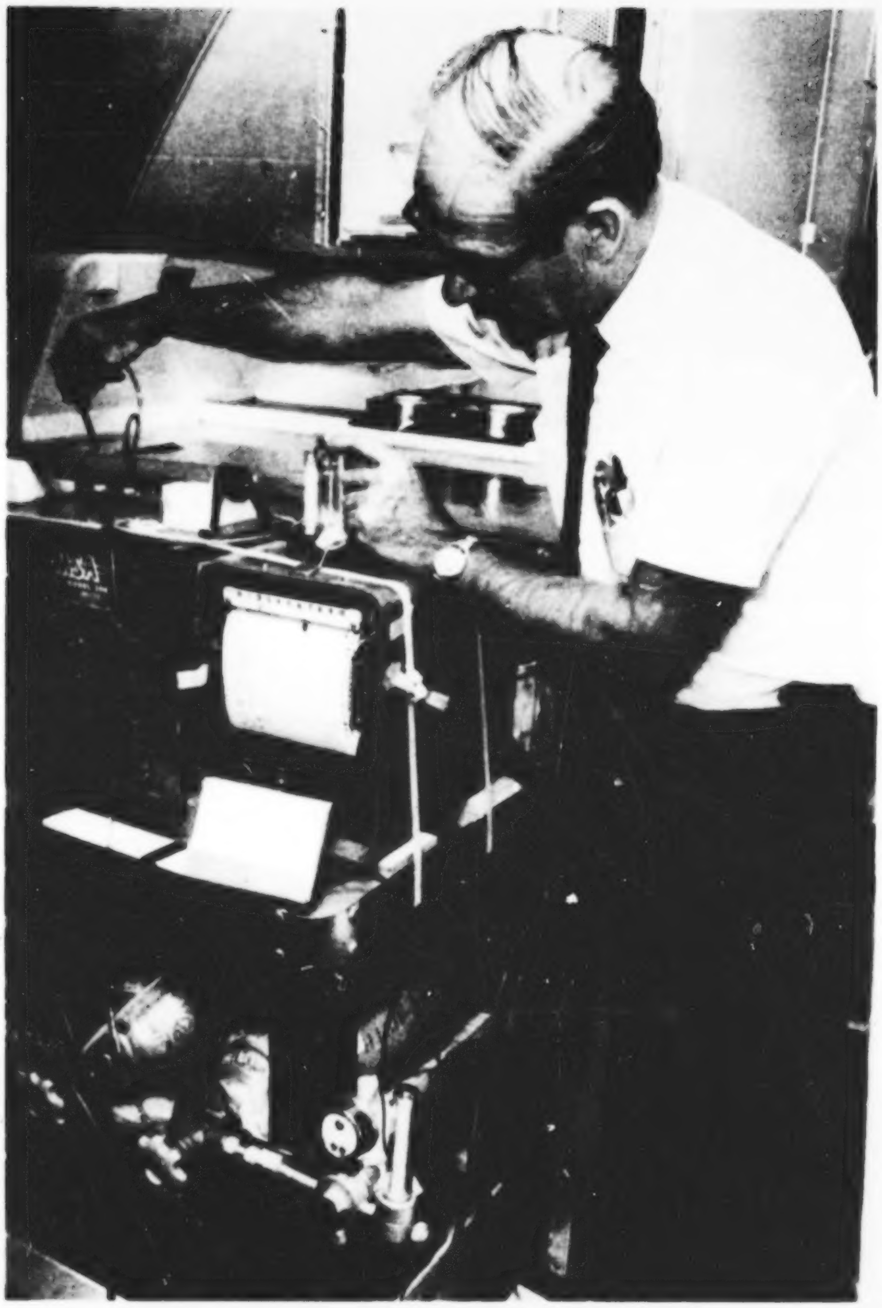


Figure 13. Equipment package installed in the galley of a United Air Lines 727 aircraft to determine the carbon monoxide concentration inside the aircraft cabin during taxiing in the wake of other aircraft in the take-off line-up. Photograph shows the instrument being calibrated.

TABLE I

AVERAGE NUMBER OF FLIGHTS(a) PER YEAR AT LAX, 1970

Los Angeles International Airport (LAX) is located at Century
Boulevard and Sepulveda Boulevard, Los Angeles, California.

PISTON POWERED					
FOUR ENGINE	TWO(b) ENGINE	SINGLE(c) ENGINE	HELICOPTERS	JET POWERED	TOTAL FLIGHTS PER YEAR
1,825	58,400	78,110	8,760	402,960	550,055

(a) "Flight" means either an arrival or a departure.
(b) 12,500 pounds and heavier aircraft.
(c) Includes twin engine aircraft lighter than 12,500 pounds.

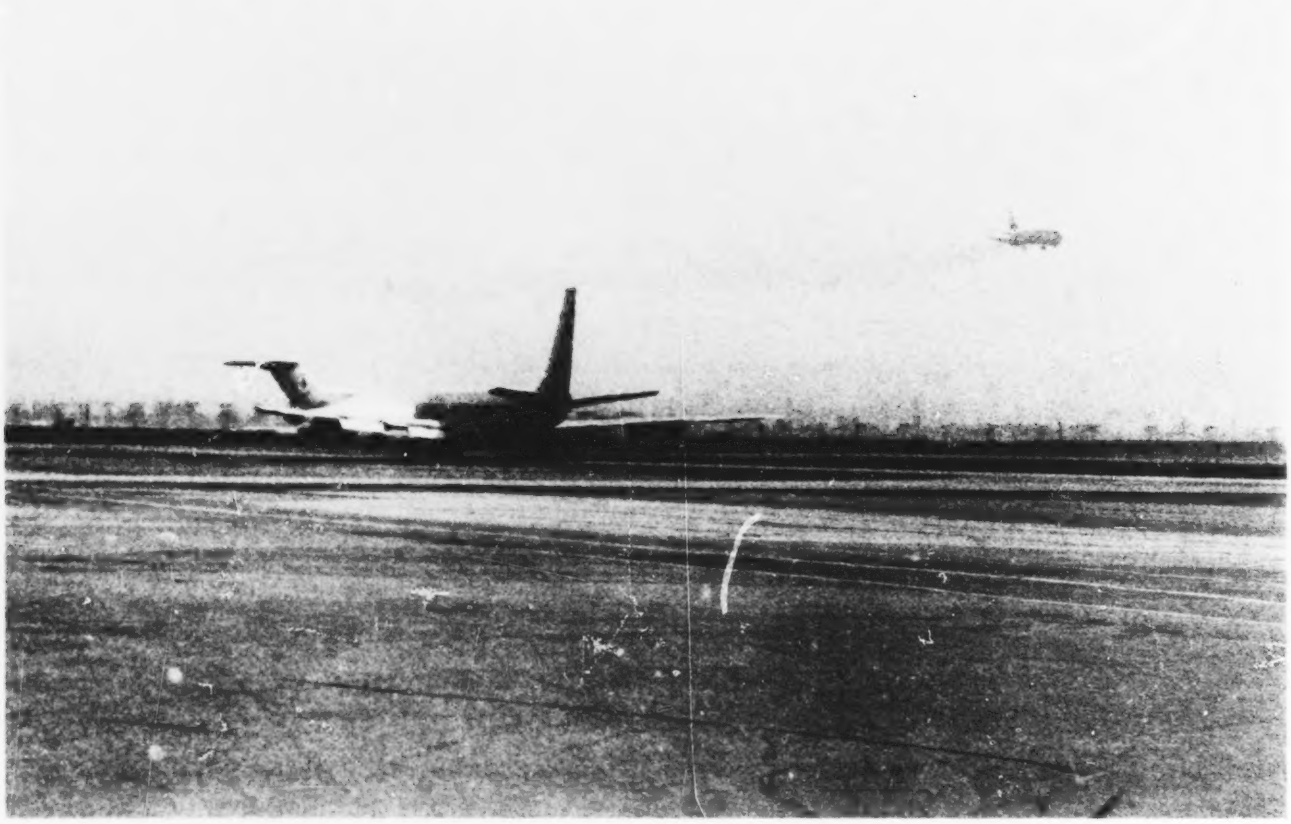


Figure 14. View of the exhaust plume from a jet aircraft during descent just prior to touchdown on one of the south runways. Photograph also shows the reduced visibility looking south from LAX.

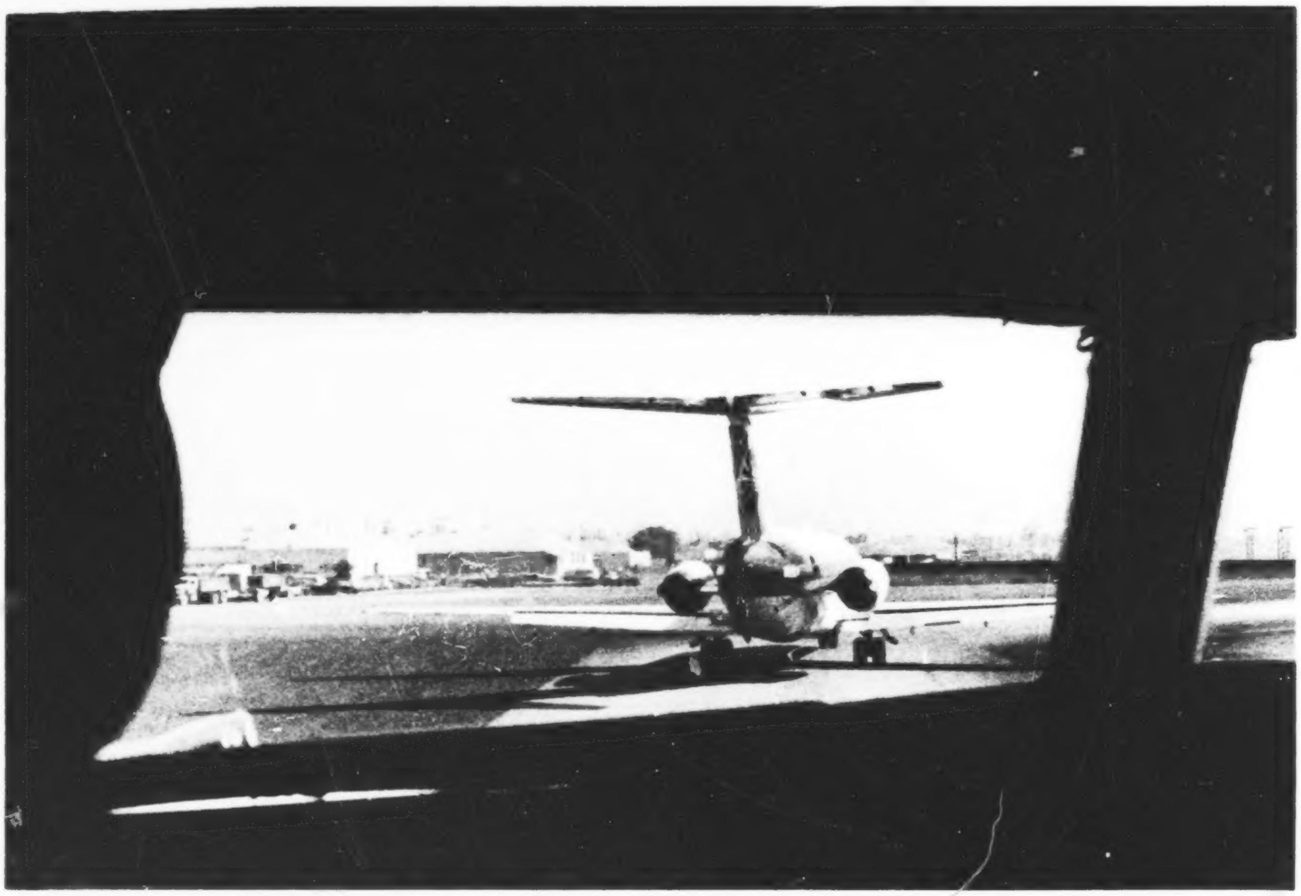


Figure 15. Pilot's view from inside the cockpit of a United Air Lines 727 on the taxiway, in the line-up, awaiting take-off. There are no visible emissions from the aircraft taxiing immediately ahead.

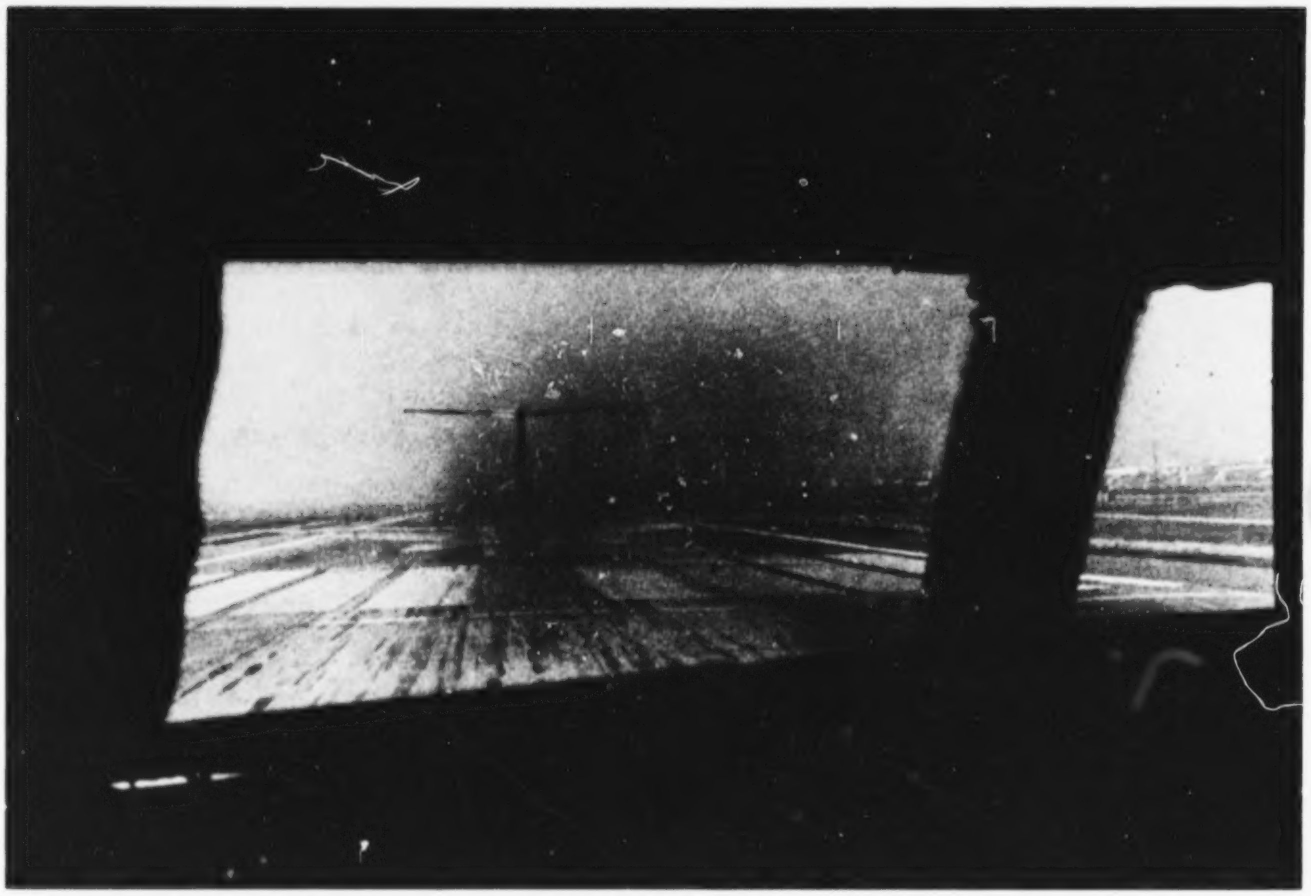


Figure 16. Pilot's view from the cockpit of a United Air Lines 727 as the aircraft ahead begins to take off. The exhaust plume almost completely obscures the aircraft taking off.

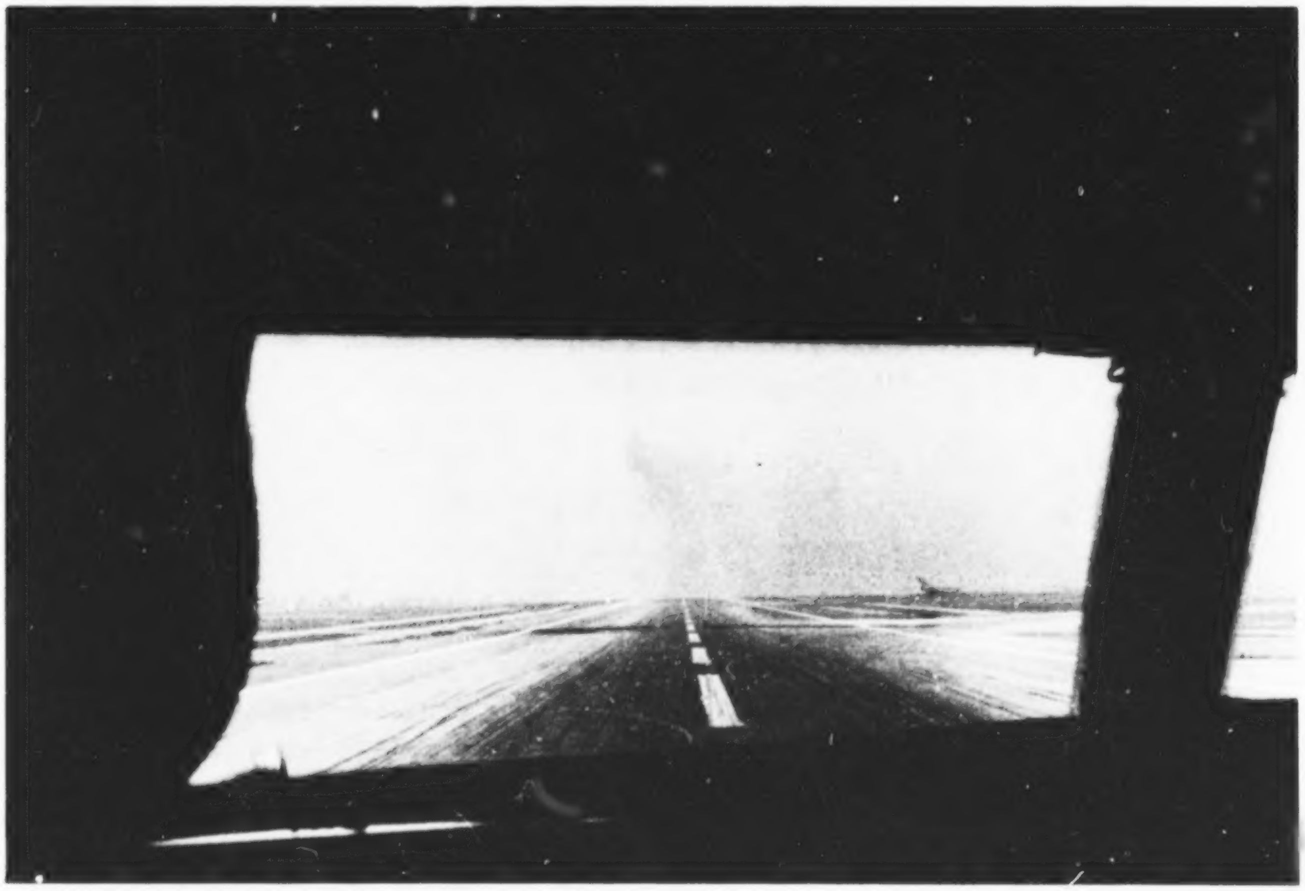
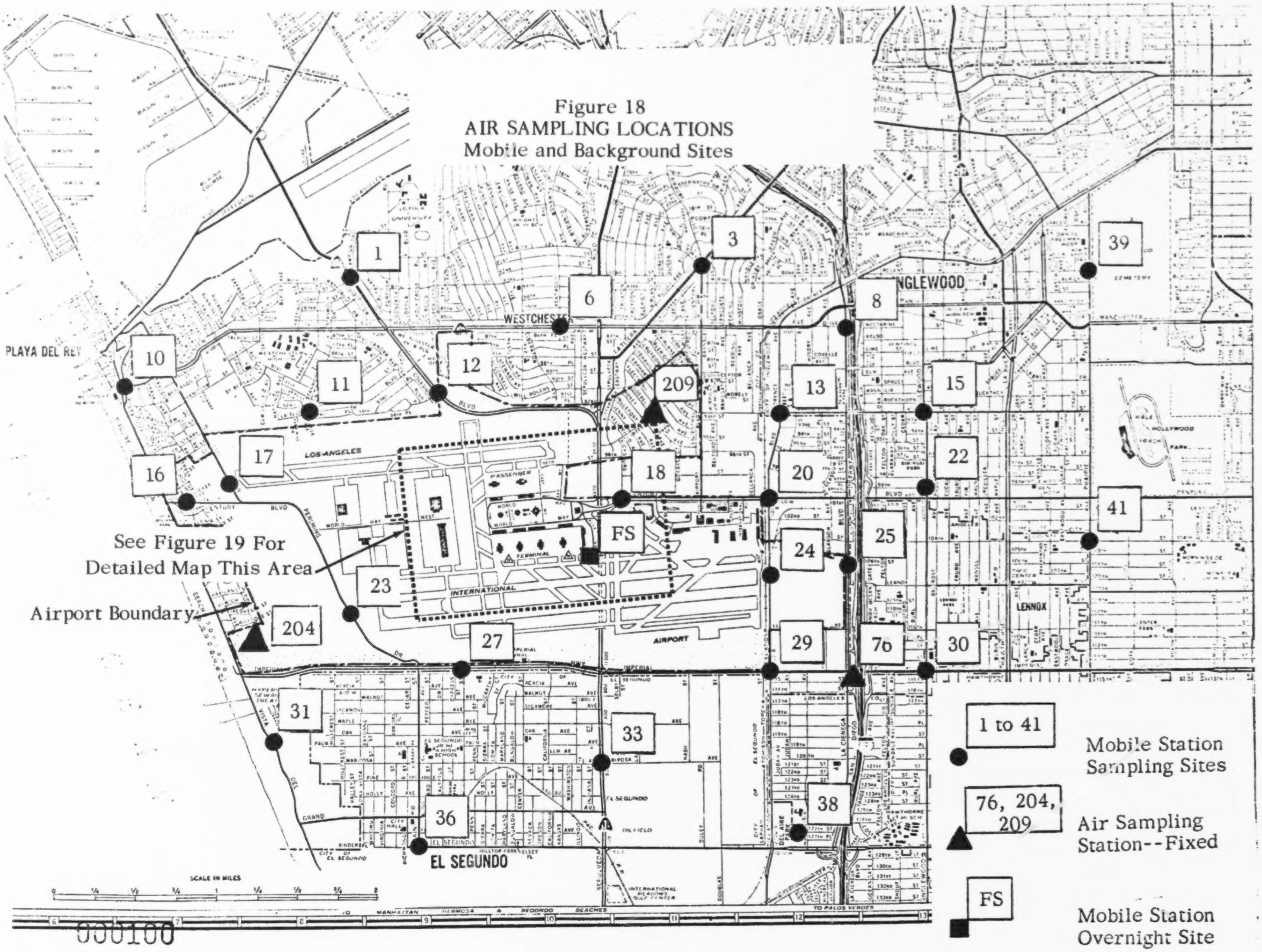


Figure 17. Pilot's view from the cockpit of a United Air Lines 727 in take-off position. The exhaust plume from the ascending aircraft greatly reduces the visibility.

Figure 18
AIR SAMPLING LOCATIONS
Mobile and Background Sites


PLAYA DEL REY
WESTCHESTER
INGLEWOOD
LENNOX
EL SEGUNDO
LOS ANGELES
INTERNATIONAL
AIRPORT
PASSENGER
TERMINAL
HOLLYWOOD PARK
CEMETERY
LOYOLA UNIVERSITY
1
3
6
8
10
11
12
13
15
16
17
18
20
22
23
24
25
27
29
30
31
33
36
38
39
41
76
204
209
FS
See Figure 19 For
Detailed Map This Area
Airport Boundary
SCALE IN MILES
0
1/4
1/2
3/4
1
2
1 to 41
Mobile Station
Sampling Sites
76, 204,
209
Air Sampling
Station--Fixed
FS
Mobile Station
Overnight Site

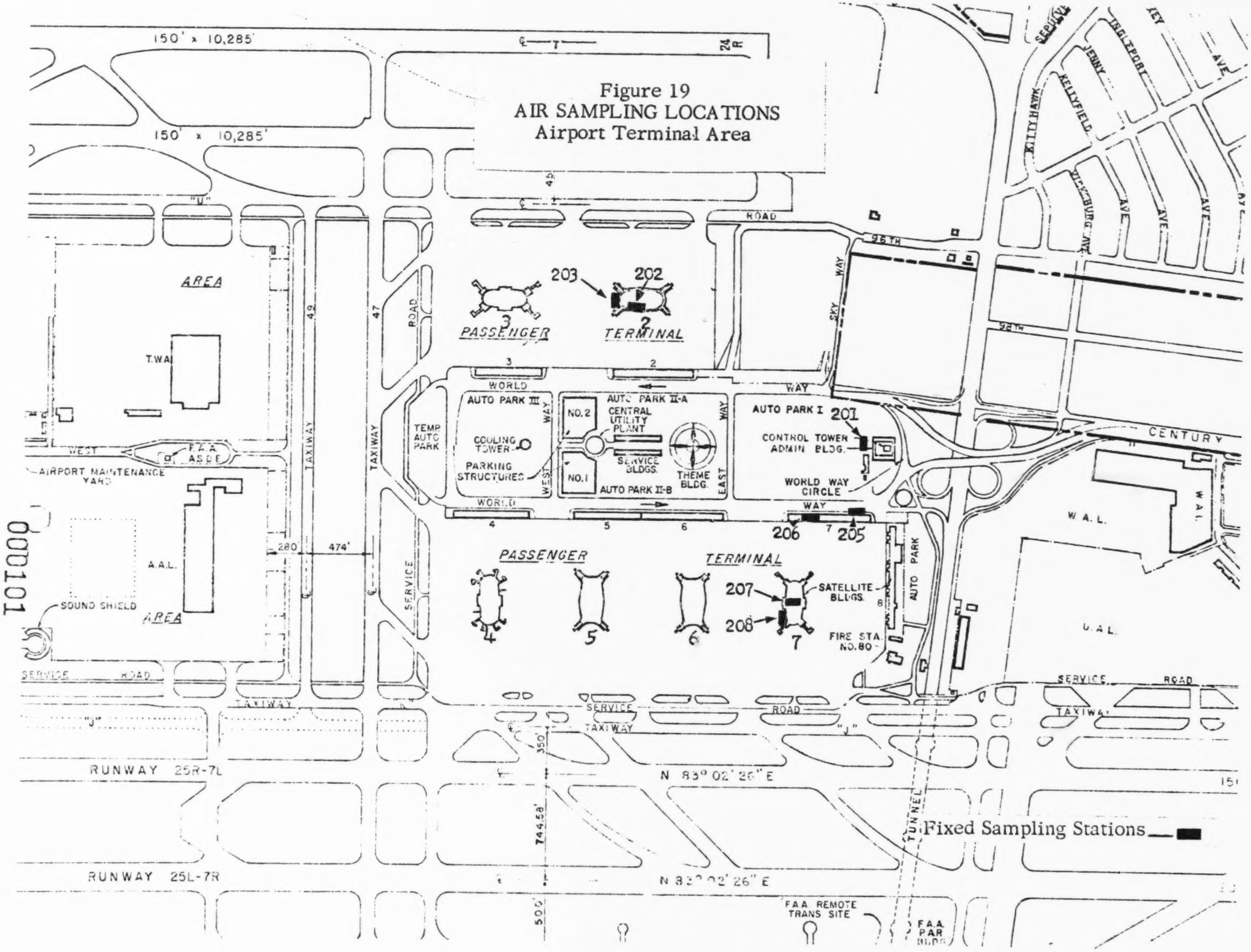


Figure 19
AIR SAMPLING LOCATIONS
Airport Terminal Area

Fixed Sampling Stations

150' x 10,285'
150' x 10,285'
24R
45
"U"
ROAD
96TH
SKY WAY
98TH
CENTURY
KITTYHAWK
KELLYFIELD
JENNY
INGLEPORT
VICKSBURG AVE
AVE
AVE
AVE
SEPULVEDA
AREA
T.WA
WEST
F.A.A. ASDE
AIRPORT MAINTENANCE YARD
A.A.L.
AREA
SOUND SHIELD
SERVICE ROAD
TAXIWAY 49
TAXIWAY 47
ROAD
SERVICE
280'
474'
203
202
3
2
PASSENGER
TERMINAL
WORLD WAY
AUTO PARK III
COOLING TOWER
PARKING STRUCTURES
TEMP AUTO PARK
NO.2
NO.1
AUTO PARK II-A
CENTRAL UTILITY PLANT
SERVICE BLDGS.
AUTO PARK II-B
THEME BLDG.
WEST WAY
EAST WAY
AUTO PARK I
201
CONTROL TOWER ADMIN BLDG.
WORLD WAY CIRCLE
206
205
4
5
6
7
8
PASSENGER
TERMINAL
207
208
SATELLITE BLDGS.
FIRE STA. NO.80
AUTO PARK
W.A.L.
W.A.L.
U.A.L.
SERVICE ROAD
TAXIWAY
"J"
SERVICE ROAD
TAXIWAY
"J"
TUNNEL
350'
744.58'
500'
RUNWAY 25R-7L
N 83° 02' 26" E
RUNWAY 25L-7R
N 83° 02' 26" E
FAA REMOTE TRANS SITE
FAA PAR BLDG.

Figure 20
FREQUENCY DISTRIBUTION Km PARTICULATE LEVELS
STATIONS 204 (Background Upwind) AND 208 (Outside Satellite 7)
June And October, 1970 (All Hours 0000-2300)

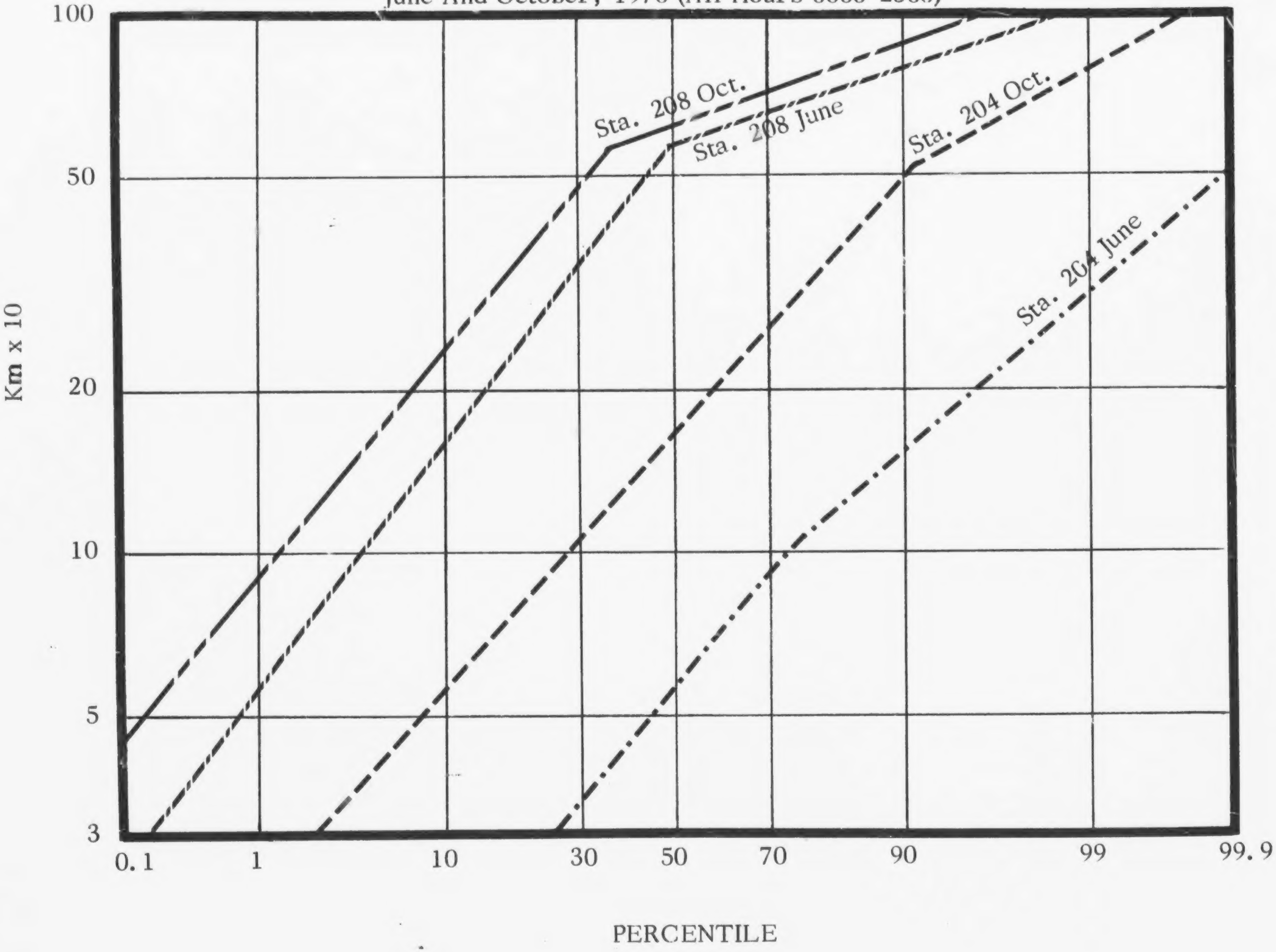


Figure 21
FREQUENCY DISTRIBUTION, CARBON MONOXIDE
STATIONS 204 AND 208
(All Hours 0000 - 2300)

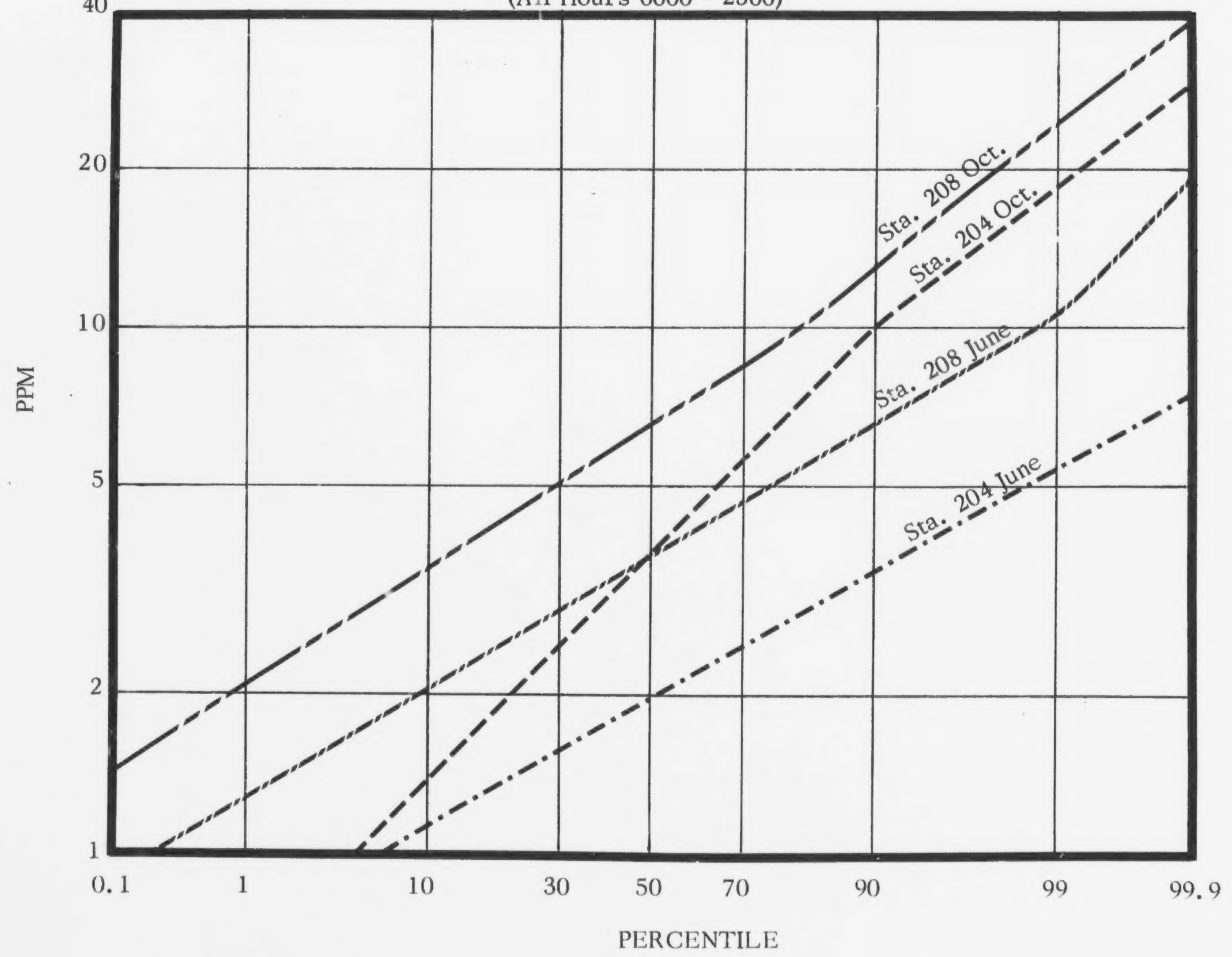
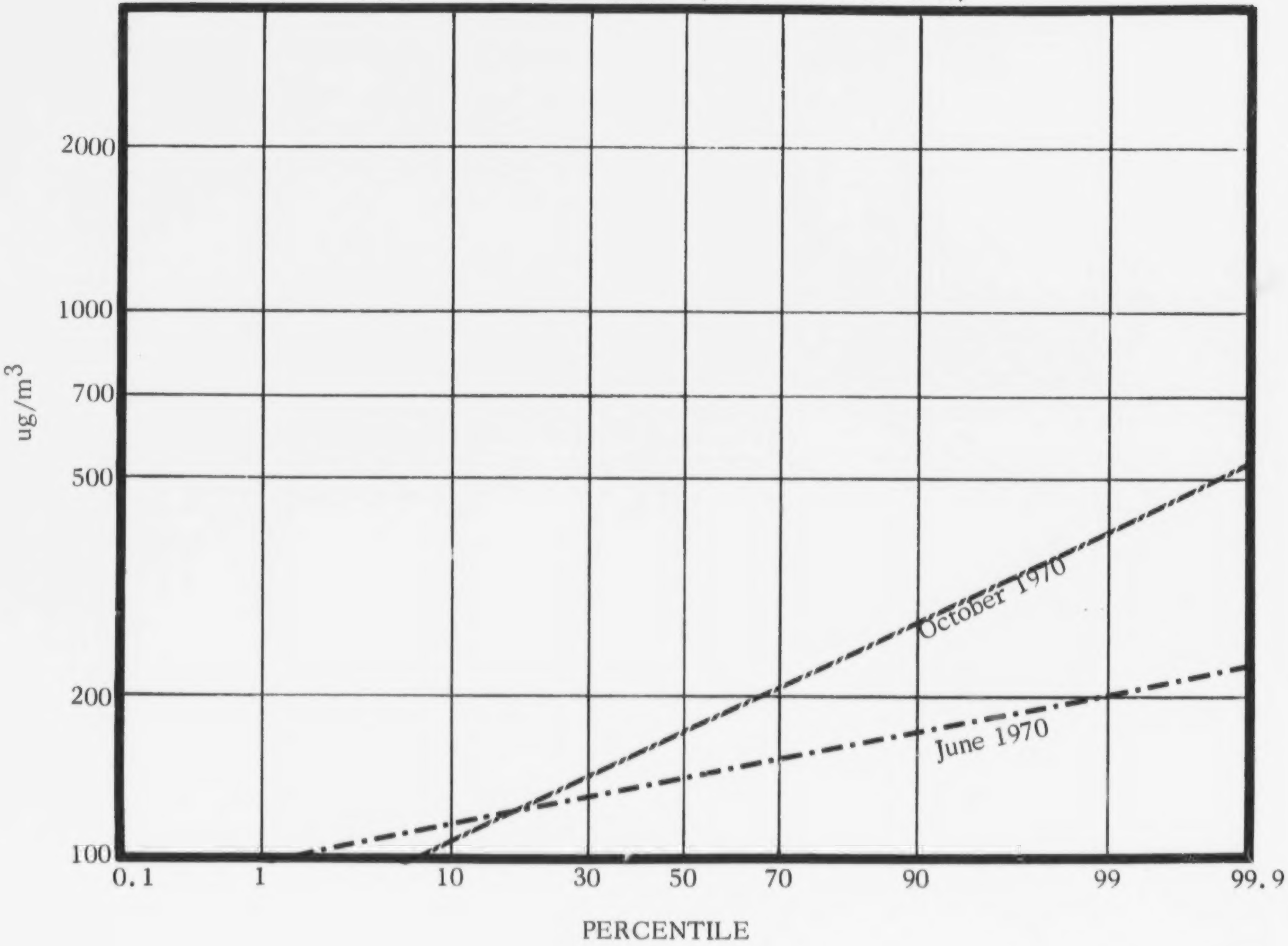
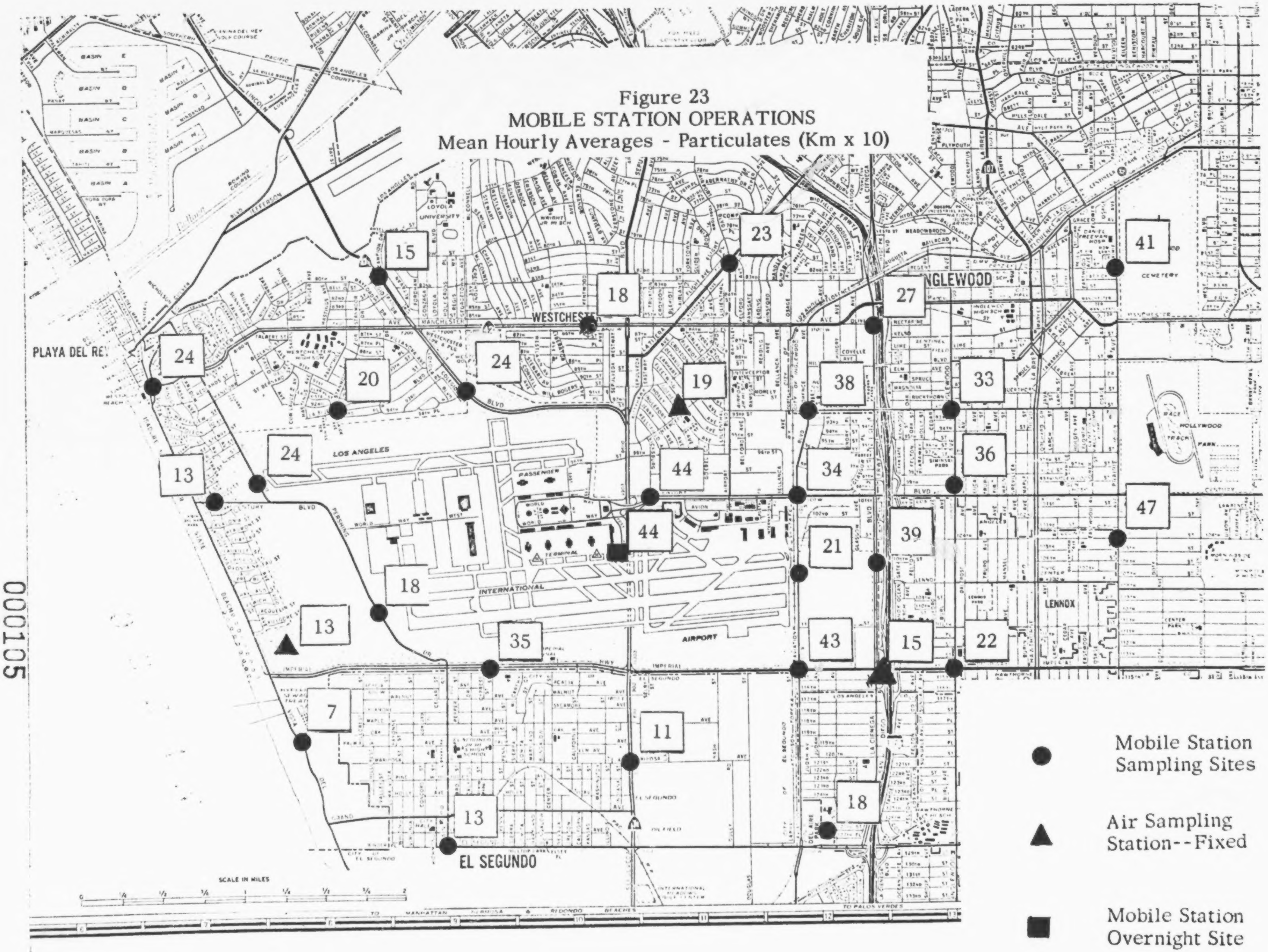


Figure 22
FREQUENCY DISTRIBUTION, HI-VOL PARTICULATE LEVELS
STATION 208 (Outside Satellite 7)
June And October, 1970 (All Hours 0000-2300)

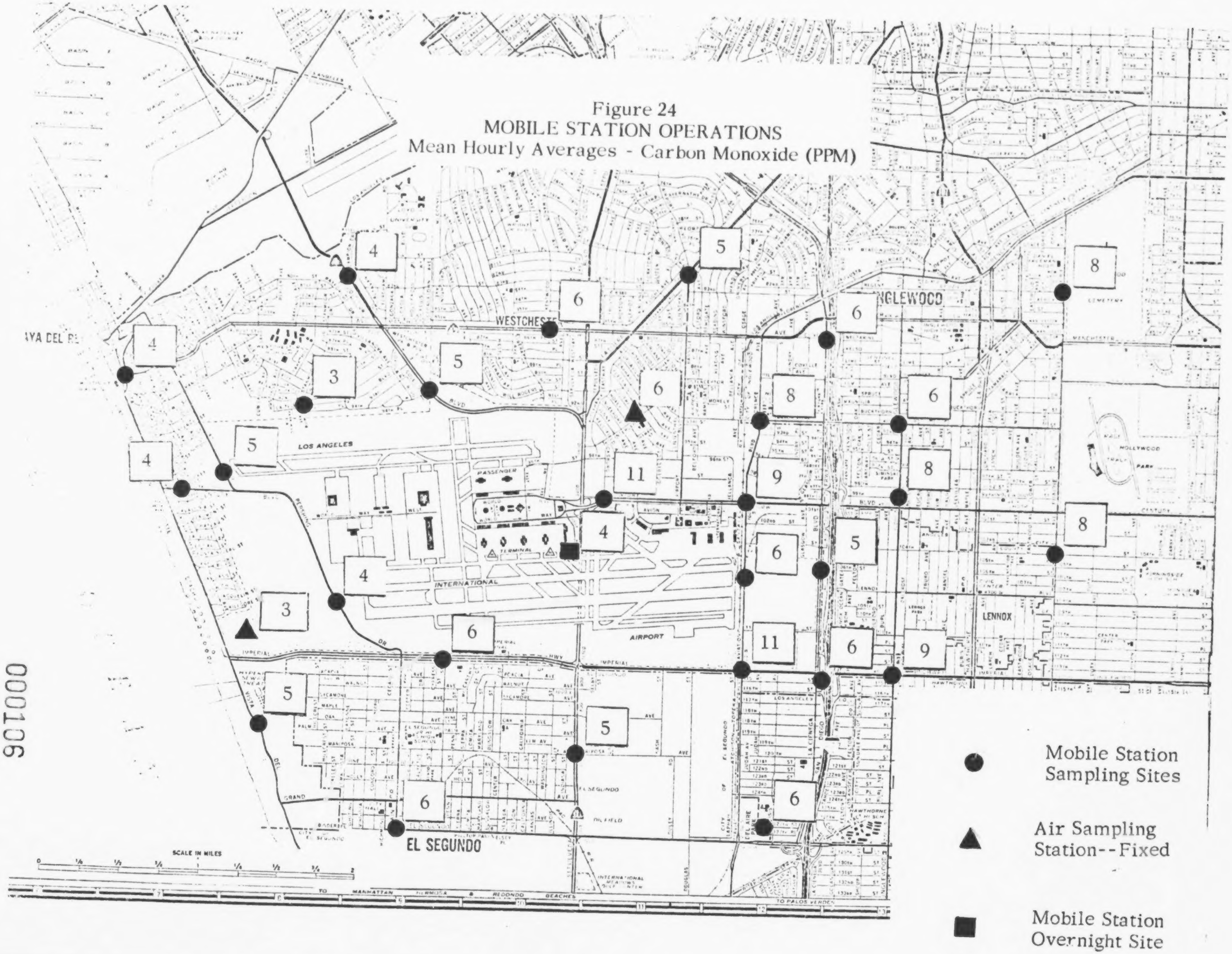




PLAYA DEL REY
WESTCHESTER
INGLEWOOD
LENNOX
EL SEGUNDO
LOS ANGELES
INTERNATIONAL
AIRPORT
LOYOLA UNIVERSITY
HOLLYWOOD PARK
CEMETERY
SCALE IN MILES
15
23
41
18
27
24
20
24
19
38
33
24
13
44
34
36
44
21
39
47
18
13
35
43
15
22
7
11
13
18
Mobile Station Sampling Sites
Air Sampling Station--Fixed
Mobile Station Overnight Site

Figure 23
MOBILE STATION OPERATIONS
Mean Hourly Averages - Particulates (Km x 10)

Figure 24
MOBILE STATION OPERATIONS
Mean Hourly Averages - Carbon Monoxide (PPM)


WESTCHESTER
INGLEWOOD
LOS ANGELES
INTERNATIONAL
AIRPORT
LENNOX
EL SEGUNDO
HOLLYWOOD PARK
IMPERIAL HWY
CENTURY
MANCHESTER
SCALE IN MILES
TO MANHATTAN HERMOSA & REDONDO BEACHES
TO PALOS VERDES
4
4
4
3
5
5
4
3
5
4
6
5
6
11
4
6
5
8
9
6
11
6
5
6
6
8
6
8
8
9
8
6
● Mobile Station Sampling Sites
▲ Air Sampling Station--Fixed
■ Mobile Station Overnight Site

APPENDIX

AIR POLLUTION CONTROL DISTRICT - COUNTY OF LOS ANGELES

TEST
CONDUCTED AT

UNITED AIR LINES
5950 AVION DRIVE
LOS ANGELES INTERNATIONAL AIRPORT
LOS ANGELES, CALIFORNIA

ON
MARCH 17, 1970

REPORT
ON THE
EMISSION OF AIR CONTAMINANTS TO THE ATMOSPHERE FROM A PRATT AND WHITNEY JT4A JET AIRCRAFT ENGINE

BY

R. M. Burlin	Senior Air Pollution Engineer
R. L. Ramlo	Air Pollution Engineer

SOURCE TESTING SECTION - ENGINEERING DIVISION
TEST REPORT NUMBER C-1500

Robert G. Lunche Director of Engineering	Howard DeVorkin Principal Engineer

Issued: May 11, 1970

INTRODUCTION:

The federal government has awarded a contract to the Air Pollution Control District to measure air contaminants in the vicinity of the Los Angeles International Airport for the purpose of determining the magnitude of air pollution originating from the operation of commercial aircraft powered by jet engines. As a part of this contract, a Pratt and Whitney JT4A jet engine as mounted and operated on a United Airlines DC8 airplane was tested to determine emission of air contaminants to the atmosphere. The engine was tested under static conditions at power settings to simulate aircraft operational modes of taxi, take-off, climb-out, and approach for landing.

Mr. Mike Takamatsu, Staff Assistant for Aircraft Maintenance at United Airlines, was visited to discuss the tests, to inspect the airplane, to arrange for a United Airlines "Cargo King" maintenance vehicle for mounting test equipment, and to provide other needed test facilities such as airplane operating and maintenance personnel. The scheduling of the airplane for test purposes was arranged by Mr. Ralph George, through United Airlines operating personnel at the San Francisco headquarters. The tests were performed on March 17, 1970 by Air Pollution Control District personnel consisting of Messrs. Y. Fushimi, R. Ramlo, J. Verssen, G. Babbitt, J. Whittaker, and R. Burlin. The report by Mr. Babbitt is appended to this report.

TEST RESULTS:

Combustion contaminants concentration in the exhaust gas to the atmosphere from a JT4A engine at each operating mode of taxi, take-off, climb-out, and approach for landing were respectively 0.61, 0.18, 0.11 and 0.21 gr/scf at 12% carbon dioxide. Other test results are shown on pages 4 through 13.

PROCESS DESCRIPTION:

The jet engine may be considered as an extremely high volume blower. Air is drawn into the front of the engine and compressed by a turbocompressor. Fuel combustion occurs inside burner cans which are equally distributed in an annular space in the engine. The hot compressed combustion gases are then expanded through turbine blades and discharged from the engine to the atmosphere. Power supplied by the turbine drives the compressor through a dual spool system. The difference in pressure across the engine (low at the inlet and high at the outlet) provides the force for moving the airplane. A picture of the DC-8 airplane showing the Number 2 engine which was tested is shown on page 3 and a sketch showing the configuration of the exhaust openings is on page 34.

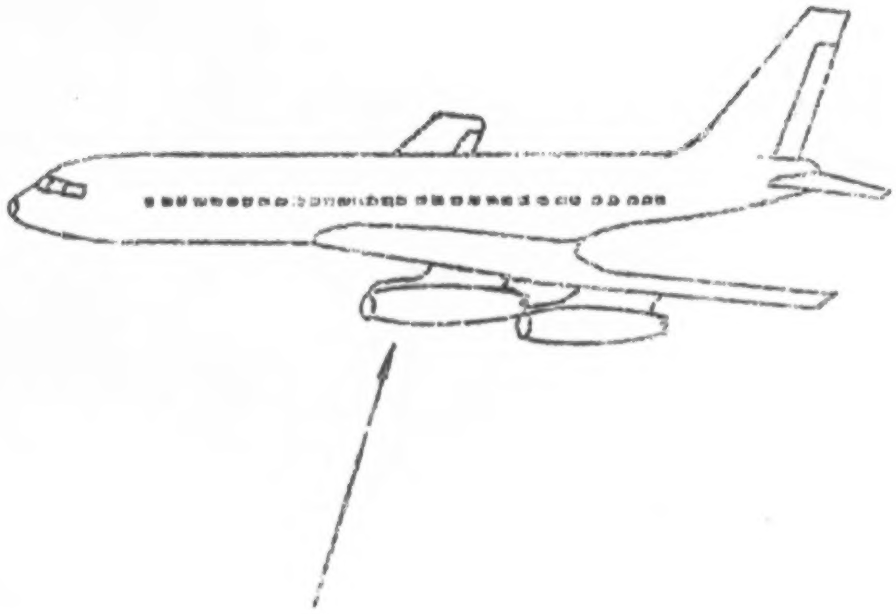
SAMPLING AND ANALYTICAL PROCEDURES:

The tests were performed according to procedures outlined in the Source Testing Manual of the Air Pollution Control District. The sampling trains and sample processing were identical to earlier tests run on jet engines during 1967-1968 (refer Test Nos. C-1133, C-1207, C-1208, C-1245, and C-1272).

Approved:

jl 4-30-70

PICTURE OF DC8 AIRPLANE



No. 2 Engine

SUMMARY OF DATA AND RESULTS

OPERATING MODE

	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
Exhaust Gas Flow Rate								
Temperature, °F	470	510	530	530	800	880	1,030	1,040
Velocity, feet per second	440	450	1,090	1,090	2,120	2,200	2,630	2,670
Velocity, Mach number	0.30	0.30	0.71	0.71	1.22	1.23	1.39	1.40
Flow rate, cfm	79,000	81,000	196,000	196,000	382,000	396,000	473,000	480,000
Flow rate, scfm	44,000	44,000	103,000	103,000	158,000	153,000	165,000	167,000
Gas Analysis								
Water vapor, vol.%	2.9	3.1	2.6	2.8	3.7	3.7	4.6	4.2
Carbon dioxide, vol.%	1.2	1.2	1.6	1.6	2.6	2.6	3.2	3.2
Oxygen, vol. %	18.7	18.7	18.3	18.3	16.6	16.6	15.7	15.7
Nitrogen, vol.%	77.2	77.0	77.5	77.3	77.1	77.1	76.5	76.9
Excess combustion air, %	1,040	1,100	800	830	430	430	340	330
Air-to-fuel ration	130	130	120	120	80	76	60	59
Fuel-to-air ratio	0.0075	0.0076	0.0082	0.0082	0.012	0.013	0.017	0.017
Air Contaminants Measured								
Particulate matter,								
grain per scf	0.050	0.073	0.029	0.025	0.019*	0.031	0.052	0.040
lb per ton fuel	25	37	13	12	6*	9	12	9
Carbon monoxide,								
ppm	550	530	140	110	71	< 10	< 10	< 10
grain per scf	0.28	0.27	0.072	0.057	0.037	<0.005	<0.005	<0.005
lb per ton fuel	140	134	33	26	11	< 2	< 1	< 1
Oxides of nitrogen,								
ppm	7	8	25	26	61	78	113	112
grain per scf	0.006	0.007	0.021	0.022	0.052	0.066	0.096	0.095
lb per ton fuel	3	4	10	10	16	19	22	21
Aldehydes,								
ppm	23	29	17	17	18	20	28	25
grain per scf	0.013	0.016	0.009	0.009	0.010	0.011	0.016	0.014
lb per ton fuel	7	8	4	4	3	3	4	3
Combustible organic gases,								
ppm (as C)	420	300	< 50	< 50	< 50	< 50	< 50	< 50
grain per scf	0.093	0.067	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
lb per ton fuel	46	33	< 5	< 5	< 3	< 3	< 3	< 3

* Test result low. Part of nozzle washing lost.

DATA SUPPLIED BY UNITED AIRLINES

Airplane type	DC 8-21	DC 8-21
Airplane number	2601*	2637**
Engine type	JT 4A	JT 4A
Engine number	2	2
Engine history:		
Total time on engine (TT) hrs.	13,304	10,350
Time since overhaul (TSO) hrs.		7,742
Next overhaul at, hrs		
Atmospheric temperature, °F	62	61
Atmospheric pressure, inches of mercury	29.94	29.85

	OPERATING MODE							
	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
Engine pressure at Pt.7, psia	15.6	15.7	20.6	20.6	31.2	31.2	36.3	36.5
Engine pressure ratio (EPR)	1.06	1.07	1.40	1.40	2.12	2.12	2.47	2.48
Exhaust gas temperature at P.7, °C	275	260	308	298	450	465	565	570
N1 rotor speed, % of maximum	31.7	31.7	64.5	64.0	84.0	84.0	91.2	91.3
N2 rotor speed, % of maximum	59.2	60.0	83.7	84.0	94.2	95.0	99.0	99.0
Fuel flow rate, lbs per hour	1,510	1,525	3,875	3,800	9,000	9,200	12,500	12,800
Engine thrust, lbs	900	950	4,700	4,700	12,200	12,200	15,600	15,650

* Airplane used for Tests 1, 2 and 3.

** Airplane used for Tests 4, 5, 6, 7 and 8.

FUEL BURNING RATE AND EXCESS COMBUSTION AIR

	OPERATING MODE							
	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
Fuel Burning Rate								
A. Exhaust gas flow rate, scfm	44,000	44,000	103,000	103,000	158,000	153,000	165,000	167,000
B. CO_2 in exhaust gas, vol.%	1.2	1.2	1.6	1.6	2.6	2.6	3.2	3.2
C. Molecular weight of fuel, lbs.	14.1	14.1	14.1	14.1	14.1	14.1	14.1	14.1
D. Fuel burning rate, lbs per hr, A x B x C/633	1,180	1,180	3,670	3,670	9,150	8,860	11,800	11,900
E. Fuel burning rate, tons per hr, D x 5 x 10^4	0.59	0.59	1.84	1.84	4.58	4.43	5.90	5.95
F. Metered fuel burning rate lb/hr	1,510	1,525	3,875	3,800	9,000	9,200	12,500	12,800
G. Discrepancy, %, 100(D-F)/F	-22	-23	-5.3	-3.4	+1.7	-3.7	-5.6	-7.0
Excess Combustion Air								
A. Oxygen in exhaust gas, vol.%	18.7	18.7	18.3	18.3	16.6	16.6	15.7	15.7
B. Carbon monoxide in exch. gas, vol.%	0.055	0.053	0.014	0.011	0.0071	<0.001	<0.001	<0.001
C. Nitrogen in exhaust gas, vol.%	77.2	77.0	77.5	77.3	77.1	77.1	76.5	76.9
D. Excess combustion air, %, 100(A-0.5B)/(0.266C-A+B)	1,040	1,100	800	830	430	430	340	330

COMPOSITION OF PARTICULATE MATTER

	OPERATING MODE							
	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A, Particulate matter emission rate, pounds per hour	19	28	26	22	26*	41	74	57
pounds per ton fuel	25	37	13	12	6*	9	12	9
B. Insoluble material, wt.%	7	4	9	31	34	27	36	38
C. Solvent residue, wt.%	34	71	12	4	8	34	7	2
D. Water residue, wt.%	50	18	39	40	47	35	55	32
E. Whatman filter, wt.%	9	7	40	25	11	4	2	28

* Test result low. Part of nozzle washing lost.

LOSS OF PARTICULATE MATTER ON IGNITION

	OPERATING MODE							
	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
Fired To 221° F								
Insoluble material, wt.% of total wt.	0	0	0	0	0	0	0	0
Solvent residue, " " " "	23	26	6	2	3	4	3	0.6
Water residue, " " " "	0	0	0	0	0	0	0	0
Total	23	26	6	2	3	4	3	0.6
Fired To 650° F								
Insoluble material, " " " "	6	3	5	10	14	6	15	14
Solvent residue, " " " "	32	67	10	4	7	28	6	1
Water residue, " " " "	26	9	20	3	20	4	24	2
Total	64	79	35	17	41	38	45	17
Fired To 1200° F								
Insoluble material, " " " "	8	4	8	17	33	22	32	34
Solvent residue, " " " "	34	71	12	4	8	34	7	2
Water residue, " " " "	44	14	29	13	30	13	39	14
Total	86	89	49	34	71	69	78	50
Fired To 1700° F								
Insoluble material, " " " "	10	4	8	19	34	23	33	35
Solvent residue, " " " "	34	71	12	4	8	34	7	2
Water residue, " " " "	46	16	33	24	35	22	45	22
Total	90	91	53	47	77	79	85	59
Filter*, wt.% of total wt.	9	7	40	25	11	4	2	28
Total	99	98	93	72	88	83	87	87

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* Filter was not fired. Material collected by filter appeared to be carbon which can be considered to be combustible.

NITROGEN OXIDES IN EXHAUST GAS
Expressed as nitrogen dioxide

	OPERATING MODE							
	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Exhaust gas flow rate, scfm	44,000	44,000	103,000	103,000	158,000	153,000	165,000	167,000
B. Water vapor in exch.gas, vol.%	2.9	3.1	2.6	2.8	3.7	3.7	4.6	4.2
C. Nitrogen oxides conc., ppm dry	7	8	26	27	63	81	119	117
D. Nitrogen oxides conc., ppm wet C(1-B/100),	7	8	25	26	61	78	113	112
E. Nitrogen oxides conc., grain/scf 8.49xDx10^{4}	0.006	0.007	0.021	0.022	0.052	0.066	0.096	0.095
F. Nitrogen oxides emission rate, lb/hr 8.57xAxEx10^{3}	2	3	19	19	70	87	136	136

ALDEHYDES IN EXHAUST GAS
Expressed as formaldehyde

OPERATING MODE

	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Exhaust gas flow rate, scfm	44,000	44,000	103,000	103,000	158,000	153,000	165,000	167,000
B. Water vapor in exch. gas, vol.%	2.9	3.1	2.6	2.8	3.7	3.7	4.6	4.2
C. Aldehyde conc., ppm dry	24	30	17	17	19	21	29	26
D. Aldehyde conc., ppm wet (C x(1-B/100),	23	29	17	17	18	20	28	25
E. Aldehyde conc., grain per scf, 5.54xDx10^{-4}	0.013	0.016	0.009	0.009	0.010	0.011	0.016	0.014
F. Aldehyde emission rate, lb/hr, 8.57 x A x E x 10^{-3}	5	6	8	8	14	14	23	20

COMBUSTIBLE ORGANIC GASES IN EXHAUST GAS
Expressed as carbon
(TCA Method)

	OPERATING MODE							
	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Exhaust gas flow rate, scfm	44,000	44,000	103,000	103,000	158,000	153,000	165,000	167,000
B. Water vapor in exch.gas, vol.%	2.9	3.1	2.6	2.8	3.7	3.7	4.6	4.2
C. Combustible org.gas conc., ppm dry	430	310	< 50	< 50	< 50	< 50	< 50	< 50
D. Combustible org. gas conc., ppm wet, C(1-B/100),	420	300	< 50	< 50	< 50	< 50	< 50	< 50
E. Combustible org. gas conc., grain/scf, 2.22xDx10^{-4}	0.093	0.067	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
F. Combustible org.gas emission rate, lb/hr, 8.57xAxEx10^{-3}	35	25	< 10	< 10	< 15	< 15	< 15	< 15

ANALYSES OF JET ENGINE FUEL

Kinematic viscosity @ 100°F, CS (ASTM D445-65)	1.506
API gravity (ASTM D 287-67)	41.71
Flash point, °F (ASTM D93 - 66)	145
Weight per cent sulfur (ASTM D129 - 64)	0.24
Weight per cent mercaptans (ASTM D1219-61)	0.0004
FIA (ASTM D 1319 - 69)	
Saturates, Volume %	83.9
Olefins, Volume %	0.8
Aromatics, Volume %	15.3
Distillation (ASTM D86 - 67)	
IBP, °F	328
10%, °F	362
20%, °F	374
50%, °F	420
90%, °F	464
End point, °F	464
Decomposition point, °F	464
Cloud point, °F	minus 14*
Pour point, °F	less than minus 70*
Luminometer Number	43.0**
BTU per pound	19,702**
Smoke point	21**
Freezing point, °F	minus 60.7**

* Analysis performed by Truesdail Laboratories, Inc.
** Analysis performed by E. W. Saybolt & Co., Inc.

VELOCITY DATA

	OPERATING MODE							
	Idle		Approach		Climb-out		Take-off	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Gas temperature, ° F	470	510	530	530	800	880	1,030	1,040
B. Velocity pressure, inches H_g	1.8	1.9	10.4	10.4	31.4	31.6	40.8	41.7
C. Gas velocity, fps, $10.7\ B^{1/2}(460+A)^{1/2}$	440	450	1,090	1,090	2,120	2,220	2,630	2,670
D. Area of flow, sq. ft.	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
E. Gas flow rate, cfm. $60 \times C \times D$	79,000	81,000	196,000	196,000	382,000	396,000	473,000	480,000
F. Gas flow rate, scfm $520 \times E/(460+A)$	44,000	44,000	103,000	103,000	158,000	153,000	165,000	167,000

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 14

SAMPLING STATION Run No. 1 (Idle) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I	V_M	P_M	T_I	V_H in Hg	Gas Temper. °F
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
10:57	24.89		TC		54.59			1.75	470
+ 3	31.3	6.3	60° F	57	61.6	6.8	54	1.8	470
+ 6	-	6.3		60	-	6.8	59	1.8	470
+ 9	45.09	6.3		61	75.51	6.8	60	1.8	470
	20.20 Net	6.3 Avg.		59 Avg	20.92 Net	6.8 Avg.	58 Avg.	1.8 Avg.	470 Avg.

(Continued on page 15)

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.08

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, ~~17.4~~ x V_M x (P_A-P_M)/(~~460+T_M~~), SCF 16.1 + 16.3 = 32.4
29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

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AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 15

SAMPLING STATION Run No. 1 (Idle) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I	V_M	P_M	T_M		
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
10:57	38.44		TC		99.71		TC		
+ 3	44.5	6.4	60° F		104.3	7.1	60° F		
+ 6	51.3	6.3			110.0	6.7			
+ 9	57.81	6.3			116.19	6.7			
	19.37	6.3			16.48	6.8			
	Net	Avg.			Net	Avg.			

MATERIAL COLLECTED Combustion contaminants

WEIGHT COLLECTED, GRAMS:

Insols. 0.0138

H_2O sols. 0.0972

C cl 4 sols. 0.0673

Whatman thimble 0.018

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.08

A. TOTAL WEIGHT 0.196

B. STACK GAS FLOW RATE, SCFM 44000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 11

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 0.51

E. GAS VOLUME METERED, ~~17.4~~ $\times V_M \times (P_A - P_M)$/(~~460+$T_M$~~), SCF 15.4+12.9+32.4 = 60.7

29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 61.2

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.050

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 19

R-1 60D484

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 16

SAMPLING STATION Run No. 5 (Idle) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	GAS METER VAC. IN. HG P_M	GAS METER TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_I	V.H. in Hg	Gas Temper. ° F
3:41	87.42		TC		23.74			1.9	520
+ 3	83.1	6.2	60	50	29.9	7.0	53	1.9	510
+ 6	98.7	6.3		54	36.1	7.0	57	1.9	510
+ 9	104.36	6.3		58	42.40	7.0	61	1.9	510
	16.94	6.3		53	18.66	7.0	57	1.9	510
	Net	Avg.		Avg.	Net	Avg.	Avg.	Avg.	Avg.

(Continued on page 17)

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.96

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, $\cancel{17.4} x V_M x \underset{29.9}{(P_A-P_M)}/(\cancel{460+T_M})$, SCF 13.4 + 14.4 = 27.8

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 17

SAMPLING STATION Run No. 5 (Idle) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_M		
3:41	6.76		TC		58.48		TC		
+ 3	12.8	6.2	60		63.6	6.9	60		
+ 6	18.9	6.4			68.7	6.9			
+ 9	25.12	6.4			73.80	6.9			
	18.36	6.3			15.32	6.9			
	Net	Avg.			Net	Avg.			

MATERIAL COLLECTED Combustion contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0102
H_2O Sols	0.0474
C cl 4 sols	0.1840
Whitman Thimble	0.019

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.96

A. TOTAL WEIGHT 0.261

B. STACK GAS FLOW RATE, SCFM 44000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 15

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 0.70

E. GAS VOLUME METERED, $17.4 \times V_M \times (P_A - P_M)/(460 + T_M)$, SCF 14.6+11.8+27.8= 54.2

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 54.9

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.073

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 28

R-1 60D484

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500

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SAMPLING STATION Run No. 2 (Approach)

DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I		P_M	T_I	V.H. in Hg	Gas Temper. °F
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
(11:25)*	40.73		TC		74.05			10.3	520
+ 3	47.6	4.0	60	51	80.-	5.2	50	10.4	520
+ 6	54.5	4.0		56	86.8	5.1	57	10.5	540
+ 9	61.51	4.1		58	93.38	5.2	59	10.5	550
	20.78	4.0		55	19.33	5.2	55	10.4	530
	Net	Avg.		Avg.	Net	Avg.	Avg.	Avg.	Avg.
* Est.									
	(Continued on page 19			-	)				

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.06

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, ~~17.4~~ x V_M x (P_A-P_M)/(~~460+T_M~~) 29.9, SCF 18.1+16.1 = 34.2

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500

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SAMPLING STATION Run No. 2 (Approach)

DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. OF T_I					
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. OF T_M		V_M	P_M	T_M		
(11:25)*	57.84		TC		16.19		TC		
+ 3	63.9	4.1	60		21.5	5.3	60		
+ 6	70.5	4.2			26.9	5.2			
+ 9	77.20	4.3			32.46	5.3			
	19.36	4.2			16.27	5.3			
	Net	Avg.			Net	Avg.			
* Est.									

MATERIAL COLLECTED Combustion contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0110
H_2O sols	0.0478
Ccl 4 sols	0.0143
Whatman thimble	0.049

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.06

A. TOTAL WEIGHT 0.122

B. STACK GAS FLOW RATE, SCFM 103000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 12

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 0.56

E. GAS VOLUME METERED, ~~17.4~~ x V_M x $(P_A - P_M)/($~~460 + T_M~~$)$, SCF 16.8+13.5+34.2= 64.5

F. TOTAL GAS VOLUME SAMPLED, D + [illegible].9, SCF 65.1

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.029

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 26

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 20

SAMPLING STATION Run No. 6 (Approach) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I	V_M	P_M	T_I	V.H. in H_g	Gas Temper. °F
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
1:04	4.44		TC		42.40			10.4	510
+ 3	9.8	3.9	60	49	48.7	5.0	51	10.4	530
+ 6	15.2	4.1		57	55.1	5.2	59	10.4	530
+ 9	20.78	4.2		60	61.61	5.3	62	10.6	530
	16.34 Net	4.1 Avg.		55 Avg.	19.21 Net	5.2 Avg.	57 Avg	10.4 Avg.	530 Avg.

(Continued on page 21)

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM 29.96

ATMOS. PRESSURE, P_A, IN. HG

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, 17.4 x V_M x $(P_A - P_M)/(460 + T_M)$, SCF 14.2+15.9= 30.1

29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500

PAGE 21

SAMPLING STATION Run No. 6 (Approach)

DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	GAS METER VAC. IN. HG P_M	GAS METER TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_M		
4:04	25.14		TC		73.80		TC		
+ 3	31.4	4.0	60		79.2	5.1	60		
+ 6	37.6	4.4			84.4	5.4			
+ 9	44.23	4.4			89.91	5.4			
	19.09	4.3			16.11	5.3			
	Net	Avg.			Net	Avg.			

MATERIAL COLLECTED Combustion contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0295
H_2O Sols	0.0378
C cl 4 sols	0.0043
Whatman thimble	0.024

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.96

A. TOTAL WEIGHT 0.096

B. STACK GAS FLOW RATE, SCFM 103000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 14

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 0.65

E. GAS VOLUME METERED, $17.4 \times V_M \times (P_A - P_M)/(460+T_M)$, SCF 16.4+13.3+30.1= 59.8

29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 60.5

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.025

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 22

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AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500

PAGE 22

SAMPLING STATION Run No. 3 (Climb-out)

DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER				V.H.	Gas
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M	TEMP. °F T_I	V_M	P_M	T_I	psig	Temper. °F
11:52	60.00		TC		93.38			15.2	790
+ 3	65.6	6.9	60	51	99.7	5.1	53	15.2	800
+ 6	71.1	7.9		58	106.0	5.1	65	15.3	800
+ 9	76.82	8.1		61	112.41	5.3	66	15.5	800
	16.82 Net	7.6 Avg.		57 Avg.	19.03 Net	5.2 Avg.	61 Avg.	15.3 Avg.	800 Avg.

(Continued on page 23)

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.04

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, ~~17.4~~ xV_Mx(P_A-P_M)/(~~460+~~T_M), SCF 12.6+15.8= 28.4

29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 23

SAMPLING STATION Run No. 3 (Climb-out) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. OF T_I	V_M	P_M	T_M		
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. OF T_M						
11:52	77.24		TC		32.46		TC		
+ 3	83.2	7.0	60		37.0	5.2	60		
+ 6	89.3	8.0			43.4	5.2			
+ 9	95.43	8.0			48.78	5.2			
	18.19	7.9			16.32	5.2			
	Net	Avg.			Net	Avg.			

MATERIAL COLLECTED Combustion contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0229	SAMPLING POINT
H_2O sols	0.0308 (low)	
C cl 4 sols	0.0050	SAMPLING NOZZLE I.D., MM
Whatman thimble	0.007	
A. TOTAL WEIGHT	0.066	ATMOS. PRESSURE, P_A, IN. HG 30.04

B. STACK GAS FLOW RATE, SCFM 158000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML (no data)

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, ~~17.4×~~ V_M x (P_A-P_M)/(~~460+T_M~~), SCF 13.5+13.5+28.4= 55.4

F. TOTAL GAS VOLUME SAMPLED, D + $\overline{29.9}$ E, SCF 55.4

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.019

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR (Test result low) 26

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 24

SAMPLING STATION Run No. 7 (Climb-out) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I	V_M	T_M	T_I	V.H. psig	Gas Temper. °F
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
4:27	20.88		TC		61.61			15.3	870
+ 3	26.6	4.2	60	56	68.0	5.3	54	15.3	880
+ 6	32.3	4.5		71	74.2	5.4	71	15.3	880
+ 9	38.13	4.7		73	80.61	5.5	73	15.3	880
	17.25	4.5		67	19.00	5.4	66	15.3	880
	Net	Avg.		Avg.	Net	Avg.	Avg.	Avg.	Avg.
					(Continued on page 25				

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.95

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, ~~17.4~~ x V_M x (P_A-P_M)/~~$(460+T_M)$~~, SCF 14.7+15.6= 30.3
29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 25

SAMPLING STATION Run No. 7 (Climb-out) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	 VAC. IN. HG P_M	 TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_M		
4:27	44.24		TC		89.91		TC		
+ 3	50.5	4.3	60		95.3	5.3	60		
+ 6	56.7	4.6			100.5	5.5			
+ 9	63.11	4.8			105.84	5.6			
	18.87	4.6			15.93	5.5			
	Net	Avg.			Net	Avg.			

MATERIAL COLLECTED Combustion contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0320
H_2O Sols	0.0412
C cl 4 sols	0.0405
Whatman Thimble	0.005

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.95

A. TOTAL WEIGHT 0.119

B. STACK GAS FLOW RATE, SCFM 153000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 14

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 0.65

E. GAS VOLUME METERED, $\cancel{17.6}4 \times V_M \times (P_A-P_M)/\cancel{(460+T_M)}$, SCF 16.1+13.1+30.3= 59.5

29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 60.2

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.031

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 41

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 26

SAMPLING STATION Run No. 4 (Take-off) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	GAS METER VAC. IN. HG P_M	GAS METER TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_I	V.H. psig	Gas Temper. °F
3:19	76.89		TC		12.41			20.0	1000
+ 2	80.8	4.6	60	60	16.6	5.3	61	20.0	1020
+ 4	84.6	4.9		61	20.8	5.5	61	20.0	1030
+ 5	87.35			68	23.73		67	20.0	1030
	10.46	4.8		63	11.32	5.4	63	20.0	1030
	Net	Avg.		Avg.	Net	Avg.	Avg.	Avg.	Avg.

(Continued on page 27)

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.98

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, ~~17.4~~ x V_M x $(P_A - P_M)$ / ~~(460 + T_M)~~ 29.9, SCF 8.8+9.3 = 18.1

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 27

SAMPLING STATION Run No. 4 (Take-off) DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. OF T_I					
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M		V_M	P_M	T_M		
3:19	95.46		TC		48.78		TC		
+ 2	99.5	4.8	60		52.4	5.4	60		
+ 4	103.8	5.0			56.0	5.5			
+ 1	106.73	5.2			58.48	5.5			
	11.27	5.0			9.70	5.5			
	Net	Avg.			Net	Avg.			

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0435
H_2O sols	0.0677
C cl 4 sols	0.0081
Whatman Thimble	0.002

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.98

A. TOTAL WEIGHT 0.121

B. STACK GAS FLOW RATE, SCFM 165000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 18

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 0.84

E. GAS VOLUME METERED, ~~17.71~~ x V_M x $(P_A - P_M)$/(~~460+T_M~~), SCF 9.5+8.0+18.1= 35.6

29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 36.4

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.052

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 74

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500

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SAMPLING STATION Run No. 8 (Take-off)

DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	 VAC. IN. HG P_M	 TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_I	V.H. psig	Gas Temper. °F
4:49	38.23		TC		80.60			20.2	1020
+ 2	42.1	4.4	60	49	84.8	5.5	48	20.2	1040
+ 4	45.9	4.7		52	89.0	5.8	51	20.3	1050
+ 5	47.86	4.8		59	91.19	5.9	58	20.3	1050
	9.63 Net	4.6 Avg.		53 Avg.	10.59 Net	5.7 Avg.	52 Avg.	20.3 Avg.	1040 Avg.

(Continued on page 29)

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.96

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, $17.4 \times V_M \times (P_A - P_M)/(460 + T_M)$, SCF 8.2+8.6= 16.8

F. TOTAL GAS VOLUME SAMPLED, D + $\overset{29.9}{E}$, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500

PAGE 29

SAMPLING STATION Run No. 8 (Take-off)

DATE 3-17-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	GAS METER VAC. IN. HG P_M	GAS METER TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_M		
4:49	63.14		TC		5.84		TC		
+ 2	67.3	4.4	60		9.4	5.6	60		
+ 2	71.5	4.8			12.9	5.7			
+ 1	73.70	4.8			14.75	5.7			
	10.56	4.7			8.91	5.7			
	Net	Avg.			Net	Avg.			

MATERIAL COLLECTED Combustion contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0339
H_2O sols	0.0277
C cl 4 sols	0.0015
Whatman thimble	0.025

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.96

A. TOTAL WEIGHT 0.088

B. STACK GAS FLOW RATE, SCFM 167000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 19

D. WATER VAPOR CONDENSED, VAPOR VOLUME, C.0464 x C, SCF 0.88

E. GAS VOLUME METERED, ~~17.4~~ $\times V_M \times (P_A-P_M)/($~~$460+T_M$~~$)$, SCF 8.9+7.3+16.8= 33.0

29.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 33.9

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.040

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 57

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 30

SAMPLING STATION (Idle) DATE 3-17-70

WATER VAPOR AND GAS DENSITY CALCULATIONS

PERCENT WATER VAPOR IN GASES	Run 1	Run 2
A. Gas pressure at meter, in. Hg (absolute)	23.5	23.4
B. Vapor pressure of water at impinger temp., in. Hg	0.495	0.436
C. Gas volume metered, SCF	60.7	54.2
D. Water vapor metered, C X B/A, SCF	1.28	1.01
E. Water vapor condensed, vapor volume, SCF	0.51	0.70
F. Total water vapor in gas sample, D + E, SCF	1.79	1.71
G. Total gas volume sampled, C + E, SCF	61.2	54.9
H. Per cent water vapor in gas sample, 100 X F/G	2.9	3.1

GAS DENSITY CORRECTION FACTOR

COMPONENT	VOLUME PER CENT/100	X	MOISTURE CORRECTION 1 — H/100	X	MOL. WT.	=	WEIGHT PER MOLE OF STACK GAS
WATER			1.0		18.0		
CARBON DIOXIDE	DRY BASIS				44.0		
CARBON MONOXIDE	DRY BASIS				28.0		
OXYGEN	DRY BASIS				32.0		
NITROGEN & INERTS	DRY BASIS				28.2		

J. MOLECULAR WEIGHT OF STACK GAS ________

K. DENSITY OF GAS REFERRED TO AIR = J/28.95 = ________

L. GAS DENSITY CORRECTION FACTOR = $\sqrt{1.00/K}$ = ________

60D480

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500

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SAMPLING STATION (Approach)

DATE 3-17-70

WATER VAPOR AND GAS DENSITY CALCULATIONS

PERCENT WATER VAPOR IN GASES

	Run No.2	Run No.6
A. GAS PRESSURE AT METER, IN. HG (ABSOLUTE)	25.4	25.3
B. VAPOR PRESSURE OF WATER AT IMPINGER TEMP., IN. HG	0.436	0.452
C. GAS VOLUME METERED, SCF	64.5	59.8
D. WATER VAPOR METERED, C X B/A, SCF	1.11	1.07
E. WATER VAPOR CONDENSED, VAPOR VOLUME, SCF	0.56	0.65
F. TOTAL WATER VAPOR IN GAS SAMPLE, D + E, SCF	1.67	1.72
G. TOTAL GAS VOLUME SAMPLED, C + E, SCF	65.1	60.5
H. PER CENT WATER VAPOR IN GAS SAMPLE, 100 X F/G	2.6	2.8

GAS DENSITY CORRECTION FACTOR

COMPONENT	VOLUME PER CENT/100	x	MOISTURE CORRECTION 1 − H/100	x	MOL. WT.	=	WEIGHT
							PER MOLE OF STACK GAS
WATER			1.0		18.0		
CARBON DIOXIDE	DRY BASIS				44.0		
CARBON MONOXIDE	DRY BASIS				28.0		
OXYGEN	DRY BASIS				32.0		
NITROGEN & INERTS	DRY BASIS				28.2		

J. MOLECULAR WEIGHT OF STACK GAS ____________________

K. DENSITY OF GAS REFERRED TO AIR = J/28.95 = ____________________

L. GAS DENSITY CORRECTION FACTOR = $\sqrt{1.00/K}$ = ____________________

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 32

SAMPLING STATION (Climb-out) DATE 3-17-70

WATER VAPOR AND GAS DENSITY CALCULATIONS

PERCENT WATER VAPOR IN GASES

	Run 3	Run 7
A. Gas pressure at meter, in. Hg (absolute)	23.5	24.9
B. Vapor pressure of water at impinger temp., in. Hg	0.504	0.656
C. Gas volume metered, SCF	55.4	59.5
D. Water vapor metered, C X B/A, SCF	1.19	1.57
E. Water vapor condensed, vapor volume, SCF	Negative	0.65
F. Total water vapor in gas sample, D + E, SCF		2.22
G. Total gas volume sampled, C + E, SCF		60.2
H. Per cent water vapor in gas sample, 100 X F/G		3.7

GAS DENSITY CORRECTION FACTOR

Component	Volume per cent/100	x	Moisture Correction 1 − H/100	x	Mol. wt.	=	Weight Per mole of stack gas
Water			1.0		18.0		
Carbon Dioxide	Dry basis				44.0		
Carbon Monoxide	Dry basis				28.0		
Oxygen	Dry basis				32.0		
Nitrogen & inerts	Dry basis				28.2		

J. Molecular weight of stack gas

K. Density of gas referred to air = J/28.95 =

L. Gas density correction factor = $\sqrt{1.00/K}$ =

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1500 PAGE 33

SAMPLING STATION (Take-off) DATE 3-17-70

WATER VAPOR AND GAS DENSITY CALCULATIONS

PERCENT WATER VAPOR IN GASES	Run 4	Run 8
A. GAS PRESSURE AT METER, IN. HG (ABSOLUTE)	24.8	24.8
B. VAPOR PRESSURE OF WATER AT IMPINGER TEMP., IN. HG	0.580	0.398
C. GAS VOLUME METERED, SCF	35.6	33.0
D. WATER VAPOR METERED, C X B/A, SCF	0.83	0.53
E. WATER VAPOR CONDENSED, VAPOR VOLUME, SCF	0.84	0.88
F. TOTAL WATER VAPOR IN GAS SAMPLE, D + E, SCF	1.67	1.41
G. TOTAL GAS VOLUME SAMPLED, C + E, SCF	36.4	33.9
H. PER CENT WATER VAPOR IN GAS SAMPLE, 100 X F/G	4.6	4.2

GAS DENSITY CORRECTION FACTOR

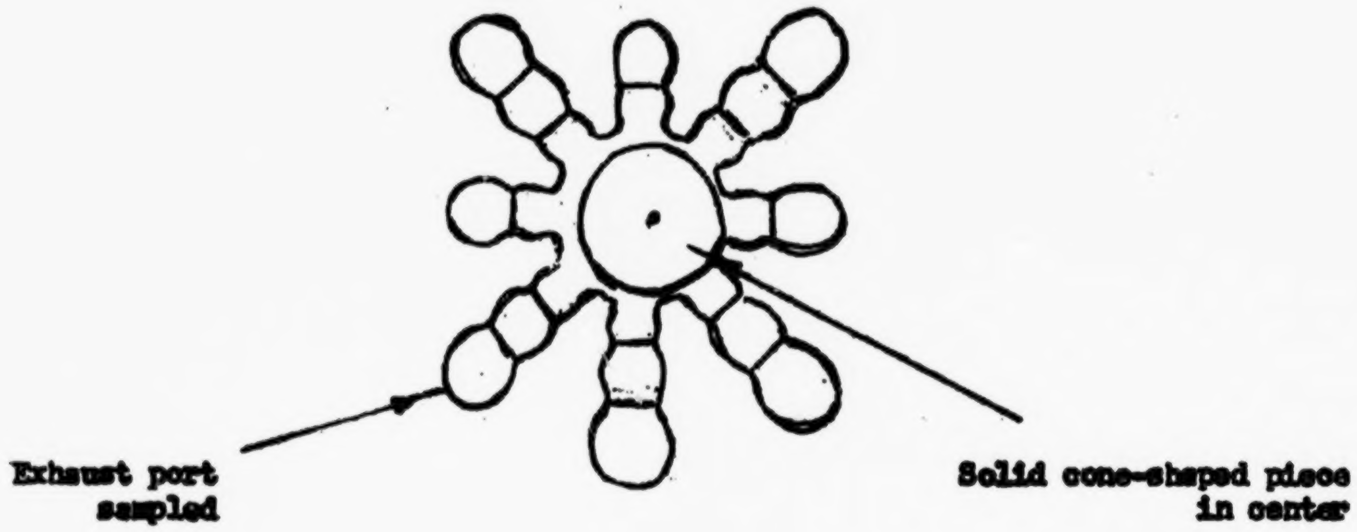
COMPONENT	VOLUME PER CENT/100	x	MOISTURE CORRECTION 1 − H/100	x	MOL. WT.	=	WEIGHT PER MOLE OF STACK GAS
WATER			1.0		18.0		
CARBON DIOXIDE	DRY BASIS				44.0		
CARBON MONOXIDE	DRY BASIS				28.0		
OXYGEN	DRY BASIS				32.0		
NITROGEN & INERTS	DRY BASIS				28.2		

J. MOLECULAR WEIGHT OF STACK GAS ____

K. DENSITY OF GAS REFERRED TO AIR = J/28.95 = ____

L. GAS DENSITY CORRECTION FACTOR = $\sqrt{1.00/K}$ = ____

SKETCH OF JT4A JET ENGINE EXHAUST OPENING CONFIGURATION


Exhaust port sampled
Solid cone-shaped piece in center

AIR POLLUTION CONTROL DISTRICT - COUNTY OF LOS ANGELES
434 SOUTH SAN PEDRO STREET, LOS ANGELES, CALIF. 90013 MADISON 9-4711

ENGINEERING DIVISION····FIELD REPORT

NAME OF APPLICANT Test No. C-1500	DATE OF INSPECTION 3-17-70
EQUIPMENT LOCATION (ADDRESS)	PERMIT APPL. NO.
SOURCE OF AIR CONTAMINANTS (#2 motors) United DC8 Jets #2601 and 2637	TYPES OF AIR CONTAMINANTS Jet exhaust;
POINT(S) OF OBSERVATION Left wing edge	POINT OF DISCHARGE
WEATHER Clear / WIND	HOURS OF OBSERVATION: FROM TO

OBSERVATIONS OF VISIBLE AIR CONTAMINANTS

TIME		INTERVAL		% OPACITY OR RINGELMANN No.	COLOR *(SEE CODE BELOW)		
FROM	TO	MINUTES	SECONDS				
11:00 am	11:09 am	9	-	0	-0-	Idle)	
11:28 am	11:37 am	9	-	0	-0-	Approach)	United #2601
11:54 am	12:03 pm	9	-	2	B	Climb out)	
3:22 pm	3:27 pm	5	-	3½	B	Take-off)	
3:44 pm	3:53 pm	9		0	-	Idle)	
4:07 pm	4:16 pm	9		-0-	-	Approach)	United #2637
4:28 pm	4:37 pm	9		2	B	Climb-out)	
4:52 pm	4:57 pm	5		3½	B	Take-off)	

← TOTAL TIME OF DISCHARGE OF AIR CONTAMINANTS OF DENSITY (OR OPACITY) OF __________ OR GREATER

*COLOR CODE:
"B" MEANS BLACK
"W" MEANS WHITE
" " ______ MEANS ______
" " ______ MEANS ______

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SIGNATURE ______________________
G.C. Babbitt

PAGE 1 OF 1 PAGES

16-50D108 R1-55-5

AIR POLLUTION CONTROL DISTRICT - COUNTY OF LOS ANGELES

TESTS
CONDUCTED AT

AMERICAN AIRLINES
7000 WORLD WAY WEST
INTERNATIONAL AIRPORT
LOS ANGELES, CALIFORNIA

ON

NOVEMBER 9 AND 18, 1970

REPORT ON THE EMISSION OF AIR CONTAMINANTS TO THE ATMOSPHERE FROM A PRATT AND WHITNEY JT9D JET AIRCRAFT ENGINE

BY

R. M. Burlin — Senior Air Pollution Engineer
W. H. Parmelee — Air Pollution Engineer

SOURCE TESTING SECTION - ENGINEERING DIVISION

TEST REPORT NUMBER C-1581

Eric E. Lemke
Director of Engineering

Howard DeVorkin
Principal Engineer

Issued December 31, 1970

INTRODUCTION

The Federal Government has awarded a contract to the Air Pollution Control District to measure air contaminants in the vicinity of the Los Angeles International Airport for the purpose of determining the magnitude of air pollution originating from the operation of commercial aircraft powered by jet engines. As a part of this contract, Pratt and Whitney JT9D fan jet engines, as mounted and operated on American Airlines Boeing 747 airplanes, were tested to determine emission of air contaminants to the atmosphere. The engines were tested under static conditions at power settings to simulate aircraft operational modes of taxi (idle), take-off, climb-out, and approach for landing. Replicate tests on two different engines were performed on November 9 and 18, 1970 (see page 7).

Mr. Harold Fleming, Superintendent of Production at American Airlines, was visited to discuss the tests, to provide maintenance vehicles for mounting test equipment, to provide other needed test facilities, to provide airplane operating and maintenance personnel, to provide the 747 airplane and engines for test purposes, and to schedule the tests. The tests were performed by Air Pollution Control District personnel consisting of Messrs. Y. Fushimi, A. Lopez, R. Ramlo, W. Parmelee, E. Reid, and R. Burlin. The reports by Mr. Lopez and Mr. Reid (visible air contaminants) are appended to this report.

TEST RESULTS

The volume flow rate of combustion gas from the JT9D fan jet engine varied from 33,000 scfm at the idle condition to 199,000 scfm at the full power take-off condition. The composition of the exhaust gas varied with the different power conditions of the engine. A typical gas analysis at the full power take-off condition gave an average of 76.1% nitrogen, 15.0% oxygen, 5.5% water vapor and 3.4% carbon dioxide.

Particulate matter emissions per ton of fuel burned averaged approximately 24 pounds for the idle condition, 16 pounds for the approach condition, 9 pounds for the climb-out condition, and 13 pounds for the take-off condition. Combustion contaminant concentrations averaged approximately 0.36, 0.25, 0.14, and 0.19 grain/scf at 12% CO_2 for the four conditions, respectively. Emissions were markedly lower for the engine tested on November 18.

Carbon monoxide emissions per ton of fuel burned averaged 106 pounds for the idle condition, 10 pounds for the approach condition, and 1 pound or less for both the climb-out and take-off conditions.

Oxides of nitrogen emissions were lowest at the idle condition (5 pounds per ton of fuel) and steadily increased with power output of the engine to a high at take-off power (52 pounds per ton of fuel).

Aldehyde emissions were quite low at all power conditions (from 3 to 7 pounds per ton of fuel).

Summaries of test results are shown on pages 6 through 15. The results of the jet fuel analysis will be available at a later date.

PROCESS DESCRIPTION

The fan jet engine may be considered as an extremely high volume gas blower. Air is drawn into the front of the engine by a turbo compressor. After some compression, most of the air (about 83 per cent) is discharged to the atmosphere around the outside of the engine while the remaining air (about 17 per cent) is further compressed and passed through the engine. Jet fuel is burned with the compressed air in an annular space within the engine. The hot compressed combustion gases are then expanded through turbine blades and discharged from the engine. Testing for flow rate and gas composition was performed for the combustion gases only. Power supplied by the turbine is used to drive the compressor through a dual spool system. The difference in pressure across the engine (low at the inlet and high at the outlet) provides the thrust or driving force of the engine.

A picture of the Boeing 747 airplane showing the Number 2 engine which was tested is shown on page 5 . The Number 3 engine was also operated during each test period at power conditions equal to the Number 2 engine. The two engines thus balanced forces on each side of the plane and prevented the plane from twisting or turning as might have occurred had only one engine been operated.

SAMPLING AND ANALYTICAL PROCEDURES

Gas Flow Rate

The volume flow rate of exhaust gas was calculated from the flow area and the gas temperature, pressure, density, and velocity. The gas velocity was calculated from velocity pressures measured by using a pitot tube and a vertical mercury manometer. The gas temperature was measured by using a chromel-alumel thermocouple and a potentiometer.

Particulate Matter

The exhaust gas was sampled at isokinetic condition and drawn through two parallel sampling trains each consisting of parallel sets of two impingers each containing 100 ml distilled water, a third impinger which was dry to serve as a trap followed by a Whatman thimble filter, two gas meters, and two pumps as shown on page 32. The impingers and the filters collected particulate matter from the gas sample. The exhaust gas was considered to be homogeneous over the annular area of the opening, and sampling was made from a point about 3 1/2 inches from the outer circumferences.

The volume of gas sampled was the sum of the metered gas volume and the volume of water vapor that was condensed in the impingers. The volume of water vapor that was condensed was calculated from the volume of condensate collected. Water vapor in the gas sample was calculated from the volume of condensate and from the water vapor that passed through the meter. In calculating the latter, the temperature in the third impinger was used as the dew point of the metered gas.

Insoluble material in the water solution from the impingers (plus distilled water and acetone used for washing and rinsing the sampling probe, impingers, and rubber tubing) was determined by drying at 221°F and weighing the solids collected after filtering the solution through an asbestos mat in a gooch crucible. Combustible or otherwise volatile material in the insolubles was determined by weight difference after firing for one-half hour in a muffle furnace at 650°F, then at 1200°F, then at 1700°F.

Solvent soluble material in the filtered solution was determined by extracting with five 25-ml portions of carbon tetrachloride solvent, and weighing the residue that remained after evaporating the solvent from the extract by a stream of dry air at room temperature. Combustible or otherwise volatile material in the residue was determined by weight difference after firing one-half hour in a muffle furnace at 650°F, then at 1200°F, then at 1700°F.

Material remaining in the water solution after filtration and after extraction was determined by weighing the residue that remained after evaporating the water at a maximum temperature of 221°F. Combustible or otherwise volatile material in the residue was determined by weight difference after firing for one-half hour in a muffle furnace at 650°F, then at 1200°F, then at 1700°F.

Material collected by each paper filter was determined by weight difference of the filter before and after the test. The weight difference was corrected for humidity effects on the filter as determined by control filters.

Nitrogen Oxides

At intervals during the test period exhaust gas samples were collected by filling evacuated two-liter glass flasks. Each flask contained 25 ml of dilute hydrogen peroxide-sulfuric acid absorbing solution.

Nitrogen oxides were determined by analyzing the absorbing solution by the phenoldisulfonic acid and colorimetric procedure according to Method APCD 12-56, and described on pages 79-82 in the APCD Source Testing Manual. Results are reported as nitrogen dioxide.

Aldehydes

At intervals during the test period, exhaust gas samples were collected by filling evacuated two-liter glass flasks. Each flask contained 10 ml of a sodium bisulfite absorbing solution.

Aldehydes were determined by analyzing the absorbing solution by an iodometric titration procedure according to Method APCD 5-46, and described on pages 72-76 in the APCD Source Testing Manual. Results are reported as formaldehyde.

Combustible Gases (CO and organic gases)

Samples were collected in dry evacuated two-liter glass flasks. The samples were analyzed for CO and organic gases by the APCD "TCA Method." (APCD Report - "Recommended Test Methods for Organic Solvents and Vapors - Rule 66" - April 1968.)

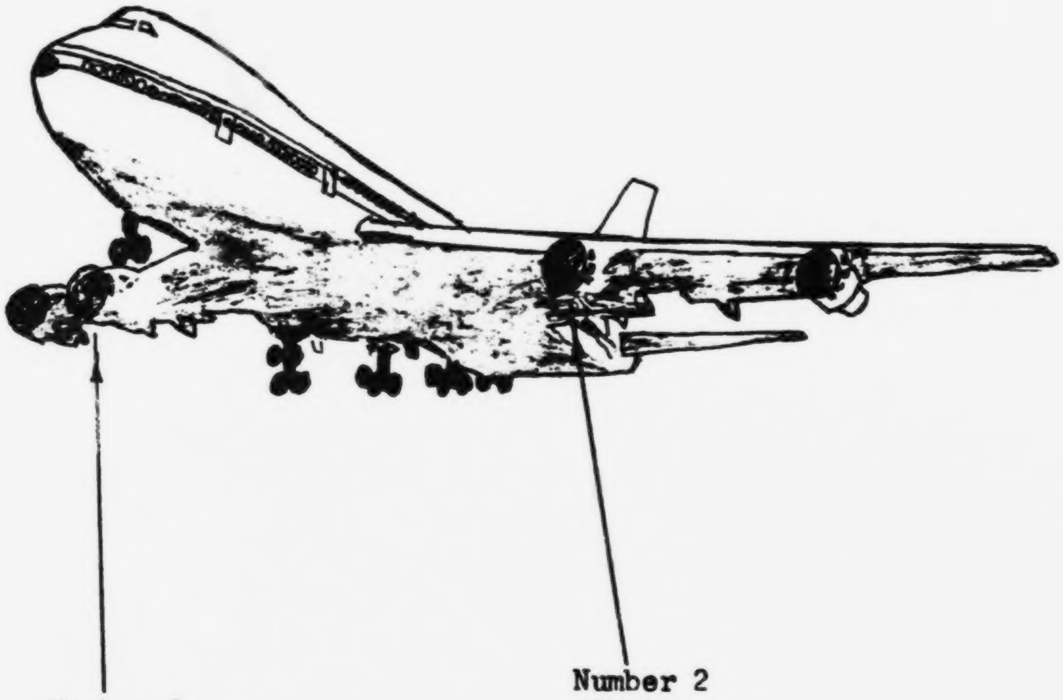
The carbon monoxide and the organic gases are reported as CO, and as equivalent carbon, respectively.

Orsat Analysis

Gas samples for Orsat analysis were collected at intervals during the test period by filling evacuated two-liter glass flasks. The samples were analyzed with a conventional Orsat analyzer.

Approved

PICTURE OF BOEING 747 AIRPLANE SHOWING THE NUMBER 2 JT9D ENGINE WHICH WAS TESTED



Number 3 Engine was run at same power conditions as Number 2 Engine to balance forces to prevent airplane from twisting or turning.

Number 2 Engine which was tested.

SUMMARY OF DATA AND RESULTS

	OPERATING MODE							
	IDLE		APPROACH		CLIMB-OUT		TAKE-OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
EXHAUST GAS FLOW RATE								
Temperature, °F	740	740	700	740	860	850	830	940
Velocity, feet per second	203	185	642	585	1120	1080	1300	1330
Velocity, Mach number	0.12	0.11	0.38	0.34	0.63	0.61	0.74	0.73
Flow rate, cfm	79000	72900	250000	230000	436000	425000	505000	525000
Flow rate, scfm	34000	32000	112000	100000	172000	169000	203000	195000
GAS ANALYSIS								
Water vapor, vol %	4.7	4.2	4.4	4.1	4.7	5.1	5.4	5.6
Carbon dioxide, vol %	2.0	2.2	2.1	2.6	2.7	3.4	3.1	3.6
Oxygen, vol %	17.1	16.9	17.0	16.4	16.2	15.1	15.4	14.7
Nitrogen, vol %	76.1	76.7	76.4	76.9	76.4	76.4	76.1	76.1
Excess combustion air, %	570	510	530	420	400	290	330	260
Air-to-fuel ratio	104	94	98	80	76	61	67	58
Fuel-to-air ratio	0.0096	0.011	0.010	0.013	0.013	0.016	0.015	0.017
AIR CONTAMINANTS MEASURED								
Particulate matter, grain per scf	0.075	0.051	0.061	0.034	0.031	0.038	0.058	0.049
, lb per ton fuel	29	18	23	10	9	9	15	11
Combustion contaminants, gr/scf at 12% CO_2	0.45	0.28	0.35	0.16	0.14	0.13	0.22	0.16
Carbon monoxide, ppm (a)	650	450	96	< 10	< 10	< 9	< 9	< 9
, grain per scf	0.34	0.23	0.050	0.005	0.005	0.005	0.005	0.005
, lb per ton fuel	130	82	19	<1.5	<1.5	<1	<1	<1
Oxides of nitrogen, ppm	18	16	56	54	150	191	238	297
, grain per scf	0.015	0.014	0.048	0.046	0.127	0.162	0.202	0.252
, lb per ton fuel	5	5	18	14	37	36	50	54
Aldehydes, ppm	(b)	12	(b)	19	(b)	54	(b)	24
, grain per scf		0.007		0.011		0.030		0.013
, lb per ton fuel		3		3		6.8		2.8
Combustible organic gases, ppm (c)	Below detection limits (<40 ppm) for all tests							
, grain per scf	Less than 0.008 gr/scf for all tests							
, lb per ton fuel	< 3	< 3	< 3	<2.5	< 2	< 2	< 2	< 2

(a) See page 13
(b) See page 12
(c) See page 14

DATA SUPPLIED BY AMERICAN AIRLINES

	Test on* 11-9-70	Test on** 11-18-70
Airplane type	747	747
Airplane number	N665	N664
Engine type	JT9-3A	JT9-3A
Engine number	2	2
Engine history:		
Total time on engine (TT), hrs.	-	-
Time since overhaul (TSO), hrs.	-	-
Next overhaul at, hrs.	-	-
Atmospheric temperature, °F	62	59
Atmospheric pressure, inches of mercury	29.92	29.80

	OPERATING MODE							
	IDLE		APPROACH		CLIMB-OUT		TAKE-OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
Engine pressure at Pt. 7, in. Hg. abs.	-	-	-	-	-	-	-	-
Engine pressure ratio (EPR)	1.02	1.02	1.10	1.10	1.29	1.29	1.41	1.41
Exhaust gas temperature at Pt. 7, °C	391	367	524	511	688	701	768	784
N_1 rotor speed, % of maximum	24	23	59	59	82	83	89	89
N_2 rotor speed, % of maximum	62	59	85	84	93.5	92	97	96
Fuel flow rate, lbs. per hr. (a)	1700	1400	5700	5500	11800	11900	15500	15600
Engine thrust, lbs.				No	Data			

(a) See also page 8 for calculated rates.

* Conducted tests 1, 2, 3, and 4.

** Conducted tests 5, 6, 7, and 8.

FUEL BURNING RATE AND EXCESS COMBUSTION AIR

	OPERATING MODE							
	IDLE		APPROACH		CLIMB - OUT		TAKE - OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
FUEL BURNING RATE								
A. Exhaust gas flow rate, scfm	34000	32000	112000	100000	172000	169000	203000	195000
B. CO_2 in exhaust gas, vol. %	2.0	2.2	2.1	2.6	2.7	3.4	3.1	3.6
C. Molecular weight of fuel, lbs.	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
D. Fuel burning rate, lbs. per hr., A x B x C/633	1510	1540	5210	5750	10300	12700	13900	15500
E. Fuel burning rate, tons per hr., D x 5 x 10^{-4}	0.76	0.77	2.6	2.9	5.2	6.4	7.0	7.8
F. Metered fuel burning rate, lbs./hr.	1700	1400	5700	5500	11800	11900	15500	15600
G. Discrepancy, %, 100(D-F)/F	-11.2	+10.0	-8.6	+4.5	-12.7	+6.7	-10.3	-0.64
EXCESS COMBUSTION AIR								
A. Oxygen in exh. gas, vol. %	17.1	16.9	17.0	16.4	16.2	15.1	15.4	14.7
B. Carbon monoxide in exh. gas, vol. %	0.065	0.045	0.0096	0.001	0.001	0.0009	0.0009	0.0009
C. Nitrogen in exhaust gas, vol. %	76.1	76.7	76.4	76.9	76.4	76.4	76.1	76.1
D. Excess combustion air, % 100(A-0.5 B)/(0.264 C-A+B)	570	510	530	420	400	290	330	260

COMPOSITION OF PARTICULATE MATTER

	OPERATING MODE							
	IDLE		APPROACH		CLIMB-OUT		TAKE-OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Particulate matter emission rate,								
pounds per hour	22	14	59	29	46	54	101	82
pounds per ton fuel	29	18	23	10	9	9	15	11
B. Insoluble material, wt. %	20	23	14	13	39	32	18	31
C. Solvent residue, wt. %	47	20	33	36	5	32	49	26
D. Water residue, wt. %	24	50	37	31	32	23	23	30
E. Whatman filter, wt. %	9	7	16	20	24	13	10	13

LOSS OF PARTICULATE MATTER ON IGNITION

	OPERATING MODE							
	IDLE		APPROACH		CLIMB-OUT		TAKE-OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
FIRED TO 221°F								
Insoluble material, wt. % of total wt.	0	0	0	0	0	0	0	0
Solvent residue, wt. % of total wt.	6	5	5	2	0.8	3	3	3
Water residue, wt. % of total wt.	0	0	0	0	0	0	0	0
CUM. - TOTAL	6	5	5	2	0.8	3	3	3
FIRED TO 650°F								
Insoluble material, wt. % of total wt.	9	11	6	5	27	20	10	19
Solvent residue, wt. % of total wt.	36	16	31	24	5	28	41	22
Water residue, wt. % of total wt.	19	19	28	13	10	12	15	18
CUM. - TOTAL	64	46	65	42	42	60	66	59
FIRED TO 1200°F								
Insoluble material, wt. % of total wt.	12	20	10	12	35	29	14	24
Solvent residue, wt. % of total wt.	46	19	32	34	5	30	47	23
Water residue, wt. % of total wt.	20	42	28	27	13	14	16	20
CUM. - TOTAL	78	81	70	73	53	73	77	67
FIRED TO 1700°F								
Insoluble material, wt. % of total wt.	12	20	10	13	37	30	15	26
Solvent residue, wt. % of total wt.	46	20	32	35	5	32	48	25
Water residue, wt. % of total wt.	21	43	29	27	19	19	20	25
CUM. - TOTAL	79	83	71	75	61	81	83	76
FILTER *, wt. % of total wt.	9	7	16	20	24	13	10	13
CUM. - TOTAL	88	90	87	95	85	94	93	89

* Filter was not fired. Material collected by filter appeared to be carbon and can be considered to be completely combustible.

NITROGEN OXIDES IN EXHAUST GAS
Expressed as nitrogen dioxide

	OPERATING MODE							
	IDLE		APPROACH		CLIMB - OUT		TAKE - OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Exhaust gas flow rate, scfm	34000	32000	112000	100000	172000	169000	203000	195000
B. Water vapor in exh. gas, vol. %	4.7	4.2	4.4	4.1	4.7	5.1	5.4	5.6
C. Nitrogen oxides conc., ppm dry	19	17	59	56	157	201	251	315
D. Nitrogen oxides conc., ppm wet C(1 - 0.01 B),	18	16	56	54	150	191	238	297
E. Nitrogen oxides conc., grain/scf 8.49 x D x 10^{-4},	0.015	0.014	0.048	0.046	0.127	0.162	0.202	0.252
F. Nitrogen oxides emission rate, lb/hr 8.57 x A x E x 10^{-3},	4	4	46	39	190	230	350	420

ALDEHYDES IN EXHAUST GAS
Expressed as formaldehyde

	OPERATING MODE							
	IDLE		APPROACH		CLIMB - OUT		TAKE - OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Exhaust gas flow rate, scfm	34000	32000	112000	100000	172000	169000	203000	195000
B. Water vapor in exhaust gas, vol%	4.7	4.2	4.4	4.1	4.7	5.1	5.4	5.6
C. Aldehyde conc., ppm dry	* 36	13	* 27	20	* 22	57	* 19	25
D. Aldehyde conc., ppm wet C(1 - 0.01 B),	* 34	12	* 26	19	* 21	54	* 18	24
E. Aldehyde conc., grain per scf $5.54 \times D \times 10^{-4}$,	* 0.019	0.007	* 0.014	0.011	* 0.012	0.030	* 0.010	0.013
F. Aldehyde emission rate, lb/hr $8.57 \times A \times E \times 10^{-3}$	* 6	2	* 13	9	* 18	43	* 17	22

* Values considered not reliable. Analytical procedures did not conform to standard practice. (Tests 1-4)

CARBON MONOXIDE IN EXHAUST GAS

	OPERATING MODE							
	IDLE		APPROACH		CLIMB - OUT		TAKE - OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Exhaust gas flow rate, scfm	34000	32000	112000	100000	172000	169000	203000	195000
B. Water vapor in exh. gas, vol %	4.7	4.2	4.4	4.1	4.7	5.1	5.4	5.6
C. Carbon monoxide conc., ppm dry	680	470	100	<10	<10	<10	<10	<10
D. Carbon monoxide conc., ppm wet C(1 - 0.01 B),	650	450	96	<10	<10	<9	<9	<9
E. Carbon monoxide conc., grain/scf, 5.17 x D x 10^{-4},	0.34	0.23	0.050	<0.005	<0.005	<0.005	<0.005	<0.005
F. Carbon monoxide emission rate, lb/hr 8.57 x A x E x 10^{-3},	99	63	48	<5	<8	<7	<8	<8

NOTE: Numbers for tests 3, 4, 6, 7, and 8 on lines C through F represent minimum detection levels for the analytical method used. Actual concentrations and rates are lower than those numbers.

COMBUSTIBLE ORGANIC GASES IN EXHAUST GAS
(Expressed as carbon)

	OPERATING MODE							
	IDLE		APPROACH		CLIMB - OUT		TAKE - OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Exhaust gas flow rate, scfm	34000	32000	112000	100000	172000	169000	203000	195000
B. Water vapor in exh. gas, vol %	4.7	4.2	4.4	4.1	4.7	5.1	5.4	5.6
C. Combustible org. gas conc., ppm dry	<40	<40	<40	<40	<40	<40	<40	<40
D. Combustible org. gas conc., ppm wet C(1 - 0.01 B),	<38	<38	<38	<38	<38	<38	<38	<38
E. Combustible org. gas conc., grain/scf 2.22 x D x 10^{-4},	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008	<0.008
F. Combustible org. gas emission rate, lb/hr 8.57 x A x E x 10^{-3}	<2.5	<2	<8	<7	<12	<12	<15	<14

NOTE: Numbers for lines C through F represent minimum detection levels for the analytical method used. Actual concentrations and rates are lower than these numbers.

GAS VELOCITY DATA

	OPERATING MODE							
	IDLE		APPROACH		CLIMB - OUT		TAKE - OFF	
	Test 1	Test 5	Test 2	Test 6	Test 3	Test 7	Test 4	Test 8
A. Gas temperature, ^{o}F	740	740	700	740	860	850	830	940
B. Velocity pressure, inches Hg.	0.3	0.25	3.1	2.5	8.3	7.7	11.5	11.0
C. Gas velocity, fps, $10.7\ B^{\frac{1}{2}}(460 + A)^{\frac{1}{2}}$	203	185	642	585	1120	1080	1300	1330
D. Area of flow, sq. ft.	6.49	6.56	6.49	6.56	6.49	6.56	6.49	6.56
E. Gas flow rate, cfm, 60 x C x D	79000	72900	250000	230000	436000	425000	505000	525000
F. Gas flow rate, scfm, 520 x E/(460 + A)	34000	32000	112000	100000	172000	169000	203000	195000

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 16

SAMPLING STATION Idle-Test 1 DATE 11-9-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I					
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M		V_M	P_M	T_M	T_I	
Start	7.27		T-C		56.75		T-C		
+3	18.4	9.7	T-C	60	71.0	10.0	T-C	60	
+6	21.6	9.6	T-C	58	75.3	10.0	T-C	58	
+9	24.84	9.6	T-C	56	79.12	10.2	T-C	56	
	17.57	9.6		58	22.37	10.1		58	
	Net	Average		Average	Net	Average		Average	
Start	9.26				20.38				
+3		7.7	T-C	60		8.2	T-C	60	
+6		7.7	T-C	58		8.2	T-C	58	
+9	24.16	7.8	T-C	56	34.15	8.3	T-C	56	
	14.90	7.7	60	58	13.77	8.2	60	58	
	Net	Average		Average	Net	Average		Average	

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

Whatman Thimbles	0.022
Insoluble Solids	0.048
Solvent Solubles	0.112
H_2O Solubles	0.058
A. TOTAL WEIGHT	0.240

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.04

B. STACK GAS FLOW RATE, SCFM 34000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 25

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 1.16

E. GAS VOLUME METERED, $17.4 \times V_M \times (P_A - P_M)/(460 + T_M)$, SCF 12.0 + 14.8 + 11.1 + 10.0 = 47.9

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 49.1

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.075

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 22

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 17

SAMPLING STATION Idle - Test 5 DATE 11-18-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER					
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M	TEMP. °F T_I	V_M	P_M	T_M	T_I	
Start	73.05				37.22				
+3		8.0	T-C	52		7.9	T-C	52	
+6		8.0	T-C	52		7.9	T-C	52	
+9	90.02	8.0	T-C	53	55.42	7.9	T-C	53	
	16.97	8.0		52	18.20	7.9		52	
	Net	Average		Average	Net	Average		Average	
Start	76.64				89.78				
+3		8.5	T-C	52		7.8	T-C	52	
+6		8.3	T-C	52		7.6	T-C	52	
+9	93.39	8.3	T-C	53	104.89	7.6	T-C	53	
	16.75	8.4	60	52	15.11	7.7	60	52	
	Net	Average		Average	Net	Average		Average	

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

Whatman Thimbles	0.012
Insolubles	0.038
Solvent solubles	0.034
Water solubles	0.083
A. TOTAL WEIGHT	0.167

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.93

B. STACK GAS FLOW RATE, SCFM 32000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 26

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 1.20

E. GAS VOLUME METERED, $17.4 \times V_M \times (P_A - P_M)/(460 + T_M)$, SCF 12.4 + 13.4 + 12.0 + 11.2 = 49.0

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 50.2

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.051

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 14

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581

PAGE 18

SAMPLING STATION Approach - Test 2

DATE 11-9-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I	V_M	P_M	T_M	V. H. in. Hg.	Tg °F
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
Start	24.18		T-C		34.33		T-C		
+3		6.3	T-C	50		6.6	T-C	3.2	700
+6		6.3	T-C	52		6.6	T-C	3.0	700
+9	42.52	6.3	T-C	58	50.18	6.3	T-C	3.0	700
	18.34	6.3		53	15.85	6.5			
	Net	Average		Average	Net	Average			
Start	24.84				79.30				
+3	30.6	4.3	T-C	50	82.8	10.1			
+6	36.8	4.3	T-C	52	86.0	10.2			
+9	43.23	4.4	T-C	58	89.14	10.2			
	18.39	4.3	60	53	9.84	10.2	60		
	Net	Average		Average	Net	Average			

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

Whatman Thimbles	0.031
Insolubles	0.029
Solvent solubles	0.065
Water solubles	0.073
A. TOTAL WEIGHT	0.198

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.06

B. STACK GAS FLOW RATE, SCFM 112000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 29

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 1.34

E. GAS VOLUME METERED, $17.4 \times V_M \times (P_A - P_M)/(460 + T_M)$, SCF 14.5 + 12.4 + 15.7 + 6.5 = 49.1

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 50.4

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.061

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 59

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 19

SAMPLING STATION Approach - Test 6 DATE 11-18-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I	V_M	P_M	T_M	T_I	
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
Start	90.25		T-C		55.42		T-C		
+3		7.2	T-C	48	7	7.0	T-C	48	
+6		7.2	T-C	50		7.0	T-C	50	
+9	108.15	7.2	T-C	54	73.91	7.0	T-C	54	
	17.90	7.2		51	18.49	7.0		51	
	Net	Average		Average	Net	Average		Average	
Start	93.50		T-C		4.89		T-C		
+3		7.5	T-C	48		6.7	T-C	48	
+6		7.5	T-C	50		6.7	T-C	50	
+9	112.83	7.5	T-C	54	20.38	6.7	T-C	54	
	19.33	7.5	60	51	15.49	6.7	60	51	
	Net	Average		Average	Net	Average		Average	

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

Whatman Thimbles	0.025
Insolubles	0.016
Solvent solubles	0.044
Water solubles	0.039
A. TOTAL WEIGHT	0.124

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.93

B. STACK GAS FLOW RATE, SCFM 100000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 30

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 1.39

E. GAS VOLUME METERED, $17.4 \times V_M \times (P_A - P_M)/(460 + T_M)$, SCF 13.6 + 14.2 + 14.5 + 12.0 = 54.3

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 55.7

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.034

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 29

R-1 60D484

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 20

SAMPLING STATION Climbout - Test 3 DATE 11-9-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I	V_M	P_M	T_M	T_I	
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
Start	43.23		T-C		89.14		T-C		
+3	48.5	9.1	T-C	50	98.8	9.5	T-C	50	
+6	54.5	9.3	T-C	56	109.6	9.6	T-C	58	
+9	60.67	9.4	T-C	60	118.56	9.7	T-C	62	
	17.44	9.3	60	55	29.42	9.6	60	57	
	Net	Average		Average	Net	Average		Average	
					(Continued on page 21)				

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, [illegible]$_M$ x(P_A-P_M)/(29.9 [illegible]), SCF 12.1 + 20.2 = 32.3

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 21

SAMPLING STATION Climbout - Test 3 (Continued) DATE 11-9-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER					
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M	TEMP. °F T_I	V_M	P_M	T_M	V. H. in. Hg.	Tg °F
	(Continued from [illegible] 20)								
Start	42.52	6.5	T-C		50.28	7.0	T-C	8.5	880
+3		6.6	T-C			7.2	T-C	8.4	860
+6		6.6	T-C			7.2	T-C	8.2	840
+9	60.62	6.6	T-C		65.73	7.2	T-C	8.1	850
	18.10	6.6	60		15.45	7.2	60		
	Net	Average			Net	Average			

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0471
H_2O solubles	0.0379
CCl_4 solubles	0.0060
Whatman Thimbles	0.028
A. TOTAL WEIGHT	0.119

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.07

B. STACK GAS FLOW RATE, SCFM 172000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 35

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 1.6

E. GAS VOLUME METERED, $V_M x(P_A-P_M)/29.9$, SCF 14.2 + 11.8 + 32.3 = 58.3

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 59.9

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.031

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 46

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 22

SAMPLING STATION Climb out test 7 DATE 11-18-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I					
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M		V_M	P_M	T_M	T_I	
Start	8.32		T-C		73.91		T-C		
+3	14.3	6.8	T-C	47	80.1	6.8	T-C	47	
+6	20.2	6.8	T-C	51	86.3	6.8	T-C	51	
+9	26.51	6.8	T-C	53	92.64	6.8	T-C	53	
	18.19	6.8	60	50	18.73	6.8	60	50	
	Net	Average		Average	Net	Average		Average	
					(Continued on page 23)				

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, ~~17.64~~ x V_M x (P_A-P_M)/(~~xxxxx~~ 29.9, SCF 14.1 + 14.4 = 28.5

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

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AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 23

SAMPLING STATION Climb out - Test 7 DATE 11-18-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	GAS METER VAC. IN. HG P_M	GAS METER TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_M	V.H. in.Hg.	Exhaust Temp. °F
	(Continued from page 22)								
Start	12.03				20.38				
+3		7.5	T-C			6.5	T-C	7.7	840
+6		7.2	T-C			6.3	T-C	7.7	850
+9	30.78	7.3	T-C		36.27	6.4	T-C	7.7	850
	18.75	7.3	60		15.89	6.4	60		
	Net	Avg.			Net	Avg.			

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:
Insolubles - 0.0443
H_2O Sols. - 0.0327
C Cl$_4$ Sols.- 0.0439
Whatman Thimbles - 0.018

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.93

A. TOTAL WEIGHT 0.139

B. STACK GAS FLOW RATE, SCFM 169000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 43

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 2.0

E. GAS VOLUME METERED, xxxxxV_M x (P_A-P_M)/(29.9 xxxxx$_M$), SCF 14.2 + 12.5 + 28.5 = 55.2

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 57.2

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.038

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 55

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AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 24

SAMPLING STATION Take off - Test 4 DATE 11-9-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I					
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M		V_M	P_M	T_M	T_I	
Start	60.67		T-C		18.75		T-C		
+3	67.43	9.6	T-C	48	28.01	9.8	T-C	47	
+6	72.49	9.6	T-C	46	37.20	9.8	T-C	45	
	11.82	9.6	60	47	18.45	9.8	60	46	
	Net	Average		Average	Net	Average		Average	

(Continued on page 25)

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, $V_M \times (P_A - P_M) / (\overset{29.9}{\cancel{460+T_M}})$, SCF 8.1 + 12.5 = 20.6

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

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AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581

PAGE 25

SAMPLING STATION Take off - Test 4

DATE 11-9-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	GAS METER VAC. IN. HG P_M	GAS METER TEMP. °F T_M	IMPINGER TEMP. °F T_I	V	P	T	V. H. in. Hg.	Tg °F
	(Continued from page 24)								
Start	60.66		T-C		65.92		T-C		
		8.0	T-C			9.0	T-C	11.4	830
+3	66.61	8.0	T-C		71.24	9.0	T-C	11.5	810
		7.5	T-C			8.2	T-C	11.2	840
+6	72.83	7.5	T-C		76.59	8.0	T-C	12.0	840
	12.17	7.8	60		10.67	8.6	60		
	Net	Average			Net	Average			

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

Insolubles	0.0263
H20 Solubles	0.0341
CCl_4 Solubles	0.0712
Whatman Thimbles	0.015

A. TOTAL WEIGHT 0.147

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 30.08

B. STACK GAS FLOW RATE, SCFM 203000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 32

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 1.5

E. GAS VOLUME METERED, ~~XXXXX~~$V_M \times (P_A - P_M)/($~~XXXXXX~~$_M)$ 29.9, SCF 9.1 + 7.7 + 20.6 = 37.4

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 38.9

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.058

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 101

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 26

SAMPLING STATION Take off - Test 8 DATE 11-18-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M	IMPINGER TEMP. °F T_I	V_M	P_M	T_M	T_I	
Start	26.70				92.65				
+3	31.03	7.4	T-C	48	97.2	7.5	T-C	48	
Cool off		7.6	T-C	50		7.6	T-C	50	
+6	37.00	7.6	T-C	51	103.56	7.6	T-C	51	
	10.30	7.5	60	50	10.91	7.6	60	50	
	Net	Average		Average	Net	Average		Average	

(Continued on page 27)

MATERIAL COLLECTED

WEIGHT COLLECTED, GRAMS:

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG

A. TOTAL WEIGHT

B. STACK GAS FLOW RATE, SCFM

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF

E. GAS VOLUME METERED, ~~XXXXXX~~V_M x (P_A-P_M)/(29.9 ~~XXXXXX~~, SCF 7.7 + 8.1 = 15.8

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR

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AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581

PAGE 27

SAMPLING STATION Take off - Test 8

DATE 11-18-70

SAMPLING TRAIN DATA AND CALCULATIONS

TIME	GAS METER			IMPINGER TEMP. °F T_I	V_M	P_M	T_M	V. H. in. Hg.	Exhaust Temp. °F
	READING CU. FT. V_M	VAC. IN. HG P_M	TEMP. °F T_M						
	(Continued from page 26)								
	31.94		T-C		36.27		T-C		
+2		7.5				6.5		11.1	930
+4		7.7				6.6		11.1	930
+6	42.06	7.7			45.70	6.7		10.9	970
	10.12	7.6	60		9.43	6.6	60		
	Net	Average			Net	Average			

MATERIAL COLLECTED Combustion Contaminants

WEIGHT COLLECTED, GRAMS:

Insclubles	0.0321
H2O Solubles	0.0306
Solvent Solubles	0.0262
Whatman Thimbles	0.013
A. TOTAL WEIGHT	0.102

SAMPLING POINT

SAMPLING NOZZLE I.D., MM

ATMOS. PRESSURE, P_A, IN. HG 29.94

B. STACK GAS FLOW RATE, SCFM 195000

C. WATER VAPOR CONDENSED, LIQUID VOLUME, ML 28

D. WATER VAPOR CONDENSED, VAPOR VOLUME, 0.0464 x C, SCF 1.3

E. GAS VOLUME METERED, $V_M \times (P_A - P_M)/($29.9, SCF 7.5 + 7.4 + 15.8 = 30.7

F. TOTAL GAS VOLUME SAMPLED, D + E, SCF 32.0

G. MATERIAL CONCENTRATION, 15.43 x A/F, GRAINS/SCF 0.049

H. MATERIAL FLOW RATE, 0.00857 x B x G, LBS/HR 82

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581

PAGE 28

SAMPLING STATION Idle (taxi) Tests

DATE 11-9, 18-70

WATER VAPOR AND GAS DENSITY CALCULATIONS

PERCENT WATER VAPOR IN GASES	Run No. 1	Run No. 5
A. GAS PRESSURE AT METER, IN. HG (ABSOLUTE)	21.1	21.9
B. VAPOR PRESSURE OF WATER AT IMPINGER TEMP., IN. HG	0.486	0.391
C. GAS VOLUME METERED, SCF	47.9	49.0
D. WATER VAPOR METERED, C X B/A, SCF	1.1	0.88
E. WATER VAPOR CONDENSED, VAPOR VOLUME, SCF	1.2	1.2
F. TOTAL WATER VAPOR IN GAS SAMPLE, D + E, SCF	2.3	2.1
G. TOTAL GAS VOLUME SAMPLED, C + E, SCF	49.1	50.2
H. PER CENT WATER VAPOR IN GAS SAMPLE, 100 X F/G	4.7	4.2

GAS DENSITY CORRECTION FACTOR

COMPONENT	VOLUME PER CENT/100	X	MOISTURE CORRECTION 1 − H/100	X	MOL. WT.	=	WEIGHT
							PER MOLE OF STACK GAS
WATER			1.0		18.0		
CARBON DIOXIDE	DRY BASIS				44.0		
CARBON MONOXIDE	DRY BASIS				28.0		
OXYGEN	DRY BASIS				32.0		
NITROGEN & INERTS	DRY BASIS				28.2		

J. MOLECULAR WEIGHT OF STACK GAS ________

K. DENSITY OF GAS REFERRED TO AIR = J/28.95 = ________

L. GAS DENSITY CORRECTION FACTOR = $\sqrt{1.00/K}$ = ________

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 29

SAMPLING STATION Approach Tests DATE 11-9, 18-70

WATER VAPOR AND GAS DENSITY CALCULATIONS

PERCENT WATER VAPOR IN GASES

	Run No. 2	Run No. 6
A. GAS PRESSURE AT METER, IN. HG (ABSOLUTE)	23.3	22.8
B. VAPOR PRESSURE OF WATER AT IMPINGER TEMP., IN. HG	0.405	0.376
C. GAS VOLUME METERED, SCF	49.1	54.3
D. WATER VAPOR METERED, C X B/A, SCF	0.86	0.90
E. WATER VAPOR CONDENSED, VAPOR VOLUME, SCF	1.3	1.4
F. TOTAL WATER VAPOR IN GAS SAMPLE, D + E, SCF	2.2	2.3
G. TOTAL GAS VOLUME SAMPLED, C + E, SCF	50.4	55.7
H. PER CENT WATER VAPOR IN GAS SAMPLE, 100 X F/G	4.4	4.1

GAS DENSITY CORRECTION FACTOR

COMPONENT	VOLUME PER CENT/100	x	MOISTURE CORRECTION 1 − H/100	x	MOL. WT.	=	WEIGHT PER MOLE OF STACK GAS
WATER			1.0		18.0		
CARBON DIOXIDE	DRY BASIS				44.0		
CARBON MONOXIDE	DRY BASIS				28.0		
OXYGEN	DRY BASIS				32.0		
NITROGEN & INERTS	DRY BASIS				28.2		

J. MOLECULAR WEIGHT OF STACK GAS ____________________

K. DENSITY OF GAS REFERRED TO AIR = J/28.95 = ____________________

L. GAS DENSITY CORRECTION FACTOR = $\sqrt{1.00/K}$ = ____________________

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 30

SAMPLING STATION Climb out Tests DATE 11-9, 18-70

WATER VAPOR AND GAS DENSITY CALCULATIONS

PERCENT WATER VAPOR IN GASES	Run No. 3	Run No. 7
A. GAS PRESSURE AT METER, IN. HG (ABSOLUTE)	21.9	23.1
B. VAPOR PRESSURE OF WATER AT IMPINGER TEMP., IN. HG	0.452	0.363
C. GAS VOLUME METERED, SCF	58.3	55.2
D. WATER VAPOR METERED, C X B/A, SCF	1.20	0.87
E. WATER VAPOR CONDENSED, VAPOR VOLUME, SCF	1.6	2.0
F. TOTAL WATER VAPOR IN GAS SAMPLE, D + E, SCF	2.8	2.9
G. TOTAL GAS VOLUME SAMPLED, C + E, SCF	59.9	57.2
H. PER CENT WATER VAPOR IN GAS SAMPLE, 100 X F/G	4.7	5.1

GAS DENSITY CORRECTION FACTOR

COMPONENT	VOLUME PER CENT/100 x	MOISTURE CORRECTION 1 − H/100 x	MOL. WT. =	WEIGHT PER MOLE OF STACK GAS
WATER		1.0	18.0	
CARBON DIOXIDE	DRY BASIS		44.0	
CARBON MONOXIDE	DRY BASIS		28.0	
OXYGEN	DRY BASIS		32.0	
NITROGEN & INERTS	DRY BASIS		28.2	

J. MOLECULAR WEIGHT OF STACK GAS

K. DENSITY OF GAS REFERRED TO AIR = J/28.95 =

L. GAS DENSITY CORRECTION FACTOR = $\sqrt{1.00/K}$ =

AIR POLLUTION CONTROL DISTRICT -- COUNTY OF LOS ANGELES

TEST NO. C-1581 PAGE 31

SAMPLING STATION Take off Tests DATE 11-9, 18-70

WATER VAPOR AND GAS DENSITY CALCULATIONS

PERCENT WATER VAPOR IN GASES

	Run No. 4	Run No. 8
A. GAS PRESSURE AT METER, IN. HG (ABSOLUTE)	21.1	22.6
B. VAPOR PRESSURE OF WATER AT IMPINGER TEMP., IN. HG	0.318	0.363
C. GAS VOLUME METERED, SCF	37.4	30.7
D. WATER VAPOR METERED, C X B/A, SCF	0.56	0.49
E. WATER VAPOR CONDENSED, VAPOR VOLUME, SCF	1.5	1.3
F. TOTAL WATER VAPOR IN GAS SAMPLE, D + E, SCF	2.1	1.8
G. TOTAL GAS VOLUME SAMPLED, C + E, SCF	38.9	32.0
H. PER CENT WATER VAPOR IN GAS SAMPLE, 100 X F/G	5.4	5.6

GAS DENSITY CORRECTION FACTOR

COMPONENT	VOLUME PER CENT/100	x	MOISTURE CORRECTION 1 — H/100	x	MOL. WT.	=	WEIGHT PER MOLE OF STACK GAS
WATER			1.0		18.0		
CARBON DIOXIDE	DRY BASIS				44.0		
CARBON MONOXIDE	DRY BASIS				28.0		
OXYGEN	DRY BASIS				32.0		
NITROGEN & INERTS	DRY BASIS				28.2		

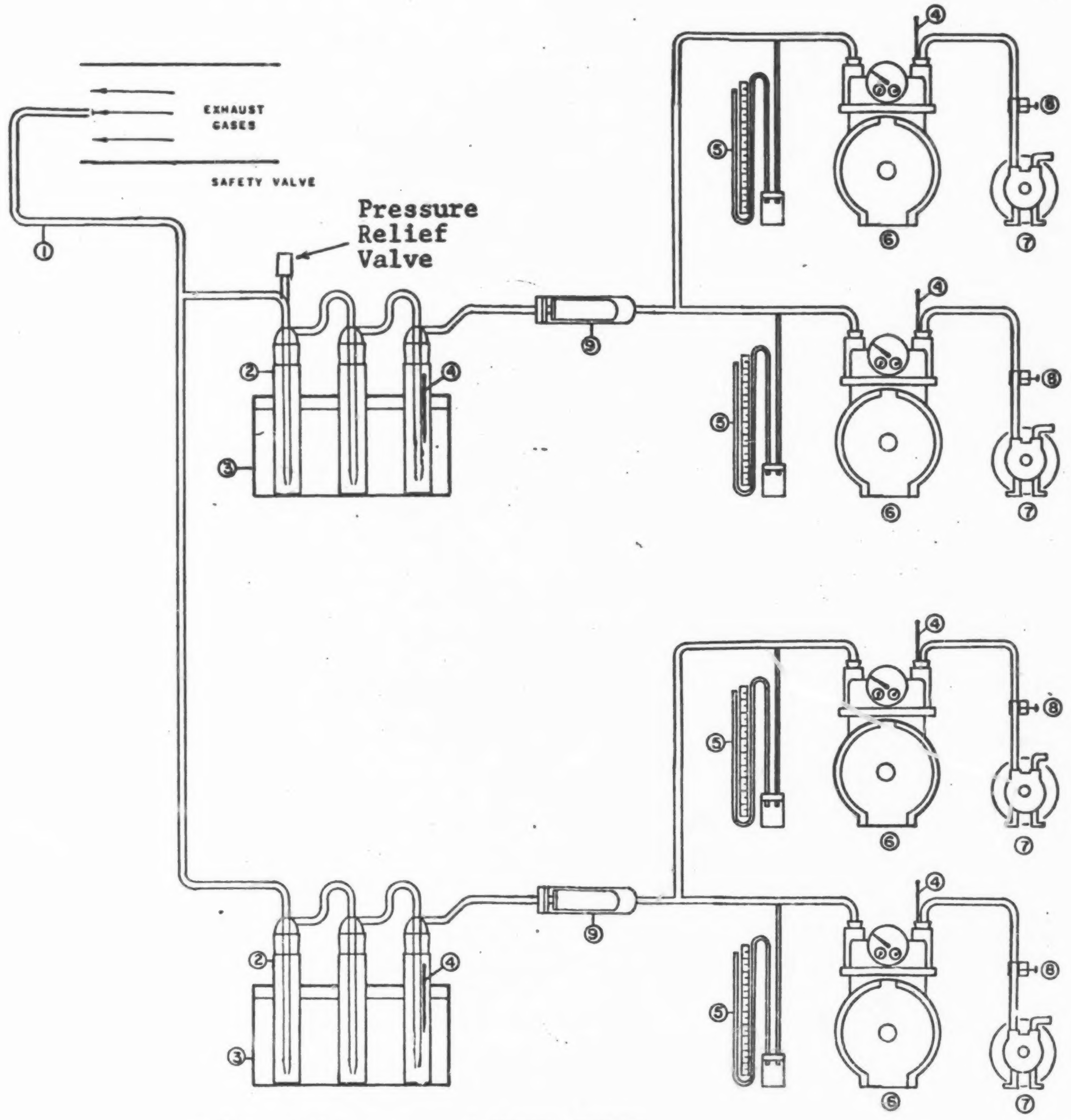
J. MOLECULAR WEIGHT OF STACK GAS

K. DENSITY OF GAS REFERRED TO AIR = J/28.95 =

L. GAS DENSITY CORRECTION FACTOR = $\sqrt{1.00/K}$ =

60D480

SAMPLING APPARATUS FOR PARTICULATE MATTER


EXHAUST GASES
SAFETY VALVE
Pressure Relief Valve
①
②
③
④
⑤
⑥
⑦
⑧
⑨

1. Sample probe
2. Modified Greenburg-Smith impinger
3. Ice-bath container
4. Thermometer
5. Mercury manometer
6. Dry gas meter
7. Air pump
8. Gas flow rate control clamp
9. Whatman thimble in pyrex holder

AIR POLLUTION CONTROL DISTRICT - COUNTY OF LOS ANGELES
434 SOUTH SAN PEDRO STREET, LOS ANGELES, CALIF. 90013 MADISON 9-4711

ENGINEERING DIVISION····FIELD REPORT

NAME OF APPLICANT: American Airlines (Test No. C-1581)

DATE OF INSPECTION: 11-9-70

EQUIPMENT LOCATION (ADDRESS): 7000 World Way West L.A. International Airport

PERMIT APPL. NO.:

SOURCE OF AIR CONTAMINANTS: 747 Jet N# 9665 engine #2

TYPES OF AIR CONTAMINANTS: Smoke

POINT(S) OF OBSERVATION: Approx: 50 ft. from source

POINT OF DISCHARGE: Jet Exhaust

WEATHER: Clear

WIND: S.W.

HOURS OF OBSERVATION: FROM 4:00 p.m. TO 8:45 p.m.

OBSERVATIONS OF VISIBLE AIR CONTAMINANTS

TIME		INTERVAL		% OPACITY OR RINGELMANN No.	COLOR *(SEE CODE BELOW)	
FROM	TO	MINUTES	SECONDS			
6:14 pm	6:25 pm	11	-	10%	Brn	All readings less than 10%
6:41	6:52	11	-	10%	Brn	All readings less than 10%
6:52	6:55	03	-	0	-	
7:48	8:00	12	-	10%	Brn	All readings less than 10%
8:00	8:06	06	-	0	-	
8:20	8:28	08	-	10%	Brn	All readings less than 10%
8:28	8:34	06	-	0	-	
8:34	8:37	03	-	10%	Brn	All readings less than 10%
		60	-	← TOTAL TIME OF DISCHARGE OF AIR CONTAMINANTS OF DENSITY (OR OPACITY) OF less than 10% OR GREATER		

*COLOR CODE:
"B" MEANS BLACK
"W" MEANS WHITE
"Brn" MEANS Brown
"____" MEANS ____

SIGNATURE ____
Armando Lopez #76

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